# Electrochemical Industry

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## Electrochemical Industry

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ADVERTISING RATES GIVEN ON APPLICATION.

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## ELECTROMETALLURGY OF GOLD.

Electrolytic methods are used in metallurgy only at a comparatively late stage of a process, since mechanical treatment or smelting processes are generally necesssary to obtain a product which can be treated successfully or economically by an electrolytic method. This is indicated by the fact that so far as commercial metallurgy is concerned, electrolysis has achieved its greatest importance in the refining industries. In general it may be said that wherever a specially pure product is wanted, electrolysis is resorted to; and the same will be the case when a material cannot be treated by the ordinary metallurgical methods. A typical instance of the latter case is the metallurgy of gold. When considering the occurrence of gold in placers, and the ease with which the bulk of it can be recovered by crushing, and when further considering the crushing of quartz in the battery, and the ease with which the bulk of the fine gold particles can be recovered by amalgamation, it is quite natural that in the metallurgy of gold no refined chemical methods were resorted to for a long while. It was only after such gold-bearing materials as tailings and slimes were produced in enormous quantities that the necessity arose to recover the gold from the same, and the cyanide process was resorted to. In the development of this process South Africa has been prominent, especially in the development of electric precipitation, and for this reason we hope that the extended review of electrometallurgy of gold in South Africa from 1897 to 1899, which is published in this issue, and which we intend to follow up by other articles covering the more recent period, will be of interest to our readers.

We have just referred to electric precipitation, as distinguished from the method of precipitation by means of zinc shavings. While this distinction is quite clear from a practical point of view, it may not be superfluous to point out that both these methods are essentially an electrochemical phenomenon. The principal difference between the two methods is that in the case of electric precipitation we use an external source of current in order to pass a current through the electrolytic tanks, while in the precipitation by means of zinc shavings we have in the precipitation vat itself an immense number of minute galvanic couples or short-circuited galvanic cells, the energy of the electric current being here derived from the chemical energy of the zinc which is being dissolved. If we short-circuit a Daniell cell, copper is deposited on the cathode plate and zinc is dissolved from the anode. If we put zinc shavings, containing impurities of lead, etc., into a cyanide solution of gold, zinc is dissolved and gold is deposited onto the impure particles of lead which act as cathodes. If a chemically pure zinc plate is immersed in a sulphuric acid solution, no dissolution of zinc is observed; but if we use a commercial zinc

plate which contains impurities, the zinc dissolves readily and hydrogen is evolved at the impurities, which are in the zinc, and which now act as cathodes. The case of the precipitation of gold by zinc shavings is quite analogous, the main difference being that in this case we have at the cathode a deposition of gold, instead of an evolution of hydrogen. This explains why chemically pure zinc is unsuitable for use in the cyanide process, and why commercial zinc which contains impurities is better and why "couples," like Ehrmann's zinc-copper couple, or the Carter-Betty zinc-lead couple are still better.

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The last-named couple appears to have aroused very great interest in 1898 in South Africa, as the discussion on the same, sketched in our article, proves. The apparently novel point in Betty's method is that he has not a zinc-lead couple pure and simple, but in combination with free cyanide. The action of the cyanide is quite evident. As was pointed out in our correspondence columns last year, by Mr. William Powell, in connection with gold plating, such addition is necessary to remove insoluble salts from the zinc surface, and the use of HCN would probably be even more effective. This fact is quite in agreement with observations made in other electrolytic processes. As Dr. J. W. Richards points out, in an article published in our January issue, the success of the Wohlwill process of gold refining, used in the Philadelphia mint, depends on the addition of free hydrochloric acid to gold chloride; when gold chloride alone is used as solution, only a fraction of the gold is dissolved from the anode, which the current should dissolve, but by acidulating strongly with hydrochloric acid the normal amount is dissolved. Another similar case is the electrolyte of lead-fluosilicate, containing an excess of fluosilicic acid, in the Betts process for refining lead.

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While the precipitation of gold from zinc shavings is thus to be considered and explained as an electrochemical phenomenon, yet for practical reasons it is convenient and preferable to restrict the use of the term electric precipitation to the case in which an electric current is passed through the precipitation vats from an external source of current, as in the Siemens & Halske process. Mr. Charles Butters' description of how this process came to the front in connection with the extremely difficult slimes problem, and how this problem was successfully solved, will be read, we are sure, with the greatest interest. It is quite probable that in future zinc precipitation and electric precipitation will continue to be operated side by side, since the one method may be preferable under certain conditions, the other method under other conditions. This was the situation in South Africa in 1899, and it has not been essentially changed in the meantime. The important problem is to clearly define the conditions under which the one or the other process is more economical, and this problem can only be solved by experimenting and recording the results.

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While all commercial applications of electrical methods in the metallurgy of gold are essentially based on first dissolving the gold in a cyanide solution, and afterwards precipitating it from the solution, we may refer here again to an entirely different method, which was described last year by Dr. W. H. Walker in an American Electrochemical Society paper. While experimenting with low-grade telluride ores from Cripple Creek, Dr. Walker wanted to determine the effect of chlorine and cyanogen at the moment of liberation at the anode, and for this purpose he had ore spread on a piece of platinum foil immersed in a solution of salt and potassium cyanide. The electrode intended to act as cathode was suspended from above. Through an error the feed wires were crossed and the platinum plate on which the ore rested, was made cathode. Almost immediately after turning on the current, gold was plated upon the platinum and a black cloud of tellurium was driven off. To prove that the anions Cl and CN played no part in this reaction, Dr. Walker substituted caustic soda as electrolyte and obtained identical results. It was thus proven that the gold was being recovered by cathodic reduction alone. The essential feature which distinguishes this reaction from the cyanide process is evident. In Dr. Walker's case there is direct reduction of gold from the ore, without a preliminary dissolution of the gold in the electrolyte.

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We have already pointed out in these columns that Dr. Walker's method is thus analogous to Mr. Salom's process of reducing lead from galena. It makes no difference whether one wants to apply the usual terminology and speak of the action of nascent hydrogen. It is clear that we have to do in both cases with direct cathodic reduction. While endeavoring, however, to work out an industrial method for treating rebellious ores in this way, Dr. Walker experienced great difficulties. Quantitative runs were made on a rather rich sulpho-telluride ore from Cripple Creek, using 5 per cent caustic soda as electrolyte, and mercury for the cathode. By maintaining good agitation it was not difficult to obtain an extraction of 93 per cent of the assay value. The presence of finely-divided tellurium in the electrolyte seemed to cause excessive flowering of the mercury, and much trouble was experienced from this cause. This kind of trouble is, of course, absent in Salom's reduction of lead, since the hydrogen sulphide gas, developed at the cathode, goes off readily.

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Dr. Walker points out the inherent difficulty of any such process for reducing gold from ore on a commercial scale. Every minute particle of mineral scattered through the relatively enormous quantity of gangue must be brought into direct contact with the cathode surface. But Dr. Walker's experiments are very valuable, since they may explain why some processes for treating tellurides of gold have promised well in the laboratory, but have failed on a commercial scale. In experiments on a test-tube scale, it is not difficult to bring a large percentage of the individual particles in direct contact with the cathode, and thus get a high extraction. But on a commercial scale the enormous quantity of worthless gangue, compared with the amount of gold particles, seems to offer very great difficulties. Moreover, former experimenters with rebellious ores, seem to have overlooked that they had to do with cathodic reduction.

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## THE MICROSTRUCTURE OF METALS AND ALLOYS.

In his interesting paper on this subject, published in the present issue, Dr. W. Campbell emphasizes a perfect truth, by saying that chemical composition is not everything, for, unless the microstructure be good, the best of materials will not make

the finished product anything but a very medium product. The importance of this fact has long been recognized by electrochemists, interested in electrolytic deposition of metals, and that our electrolytic copper refiners are fully aware of this truth and are studying the microstructure of their copper by metallographical methods, is evidenced by Mr. L. Addicks' paper, published in our December issue. What the buyers of copper wire are after, is not its chemical composition, but its properties, like electric conductivity and tensile strength; and while these properties depend on the chemical purity of the metal, yet they also depend on the treatment which the wire has undergone, since this treatment also determines the microstructure of the metal. As Mr. Addicks shows, we have in cast copper a conductivity resulting from the combined conductivities of the pure copper grains and the impure matrix and cement. When this is rolled, the structure is broken down and the complex shunt and series circuits are rearranged to better advantage. When hard-drawn, the molecular freedom is restrained and more work has to be done in the necessary oscillation of an atom in passing a charge on to its neighbor. In annealing, the wire is brought to a temperature at which the cement is softened, and all internal strain is equalized. In overheating and burning, crystalline growth is started and reverts the metal to the original condition.

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It is thus a fact that the previous treatment determines the structure of a metal. Tempering and annealing produce distinct modifications of the structure. The state of a metal is therefore not solely determined by chemical composition and temperature, as might be concluded from the diagram for iron-carbon alloys given in Dr. Campbell's article (chemical composition and temperature being the two independent variables in this diagram). In other words this diagram cannot tell the whole story in the general case. We may assume with Duhem that this diagram really represents a simplified and ideal case, being true for a perfectly annealed system. Yet, it would be quite wrong to underestimate the value of the application of Bakhuis-Roozeboom's methods of chemical thermodynamics to the discussion of solid solutions in general, and of the special case of carburized iron. By means of our diagram, which represents the main result of the application of these methods, we were first enabled to get a simple and clear classification of the different states in which carburized iron may exist under varying percentages of carbon and varying temperature.

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Metallography is a distinct science of its own, but as we have seen, the electrochemist, when specializing, is necessarily led to apply occasionally the methods of metallography, just as he is bound to use the methods of other sciences or arts in other cases. In other words, the more an electrochemist specializes, the more he will find it necessary not to be an electrochemist pure and simple, nor to restrict the methods at his disposal to those used in electrical and chemical engineering and science. The distinction made between the different sciences and arts is human work and wholly arbitrary. Nature, in every one of its phenomena is manifold, and the more we specialize in the investigation of natural phenomena, and the more we endeavor to consider every phenomenon from all possible points of view, the more we find it necessary to make use, not only of the method of one science or art, but also of those of all others. Thus, specialization is bound to lead to better appreciation of the fact that Nature is a unity which to understand we need all the different sciences together, and of the other fact that every engineering problem, to be completely solved, is to be considered not simply from the rather limited point of view of a single art; to conquer Nature for man, it needs the co-operation of all arts.

## ELECTROLYTIC DEPOSITION OF ZINC.

The short article by Dr. O. Nagel, published in this issue, on the electrolytic deposition of zinc, is very suggestive. It is probably true that in experiments made in the past on the electrolytic deposition of metals on an industrial scale, the attention was restricted too much to the one metal under consideration in each case, and that often not enough attention was paid to the results of other investigators in analogous experiments with other metals. On the other hand, we believe that much more has already been accomplished in the commercial electrolytic deposition of metals than might appear to be the case from Dr. Nagel's article. We will mention only a few instances. Lead is obtained by Mr. Betts' electrolytic process (described in our issue of August last) in a perfectly solid and dense deposit, having very nearly the same structure as electrolytically-deposited copper. Solid nickel deposits of almost any desired thickness can be obtained by Mr. Browne's method (described in our issue of June last). Concerning iron, we may only mention the fact that Mr. Edison is now able to produce the containing jars of iron for his storage battery by electrolysis with perfectly satisfactory results. It will thus be seen that much has already been accomplished in producing, on a commercial scale, satisfactory deposits of metals which are higher in the tension series than hydrogen.

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It would certainly be a praiseworthy undertaking to collect and classify all the results which have so far been obtained in this field, and to pay careful attention to the way in which the methods which have led to commercial success change from metal to metal. Then we would get a decisive answer to the question whether, as Dr. Nagel supposes, there is a parallelism between the sequence of the metals from copper to zinc, according to their tension, and the methods by which they can be technically produced by electrolysis. That the tension is one factor determining the electrolytic deposition, is self-evident. But it is another question whether the tension is such an important factor that metals of nearly equal tension can be deposited by nearly the same electrolytic method. This is a question which can only be settled by collecting the facts which are available, and by further experimenting. It seems quite possible that other factors like the characteristic structure of the metal play a more important part than its tension. Nevertheless, Dr. Nagel's suggestive proposition should be carefully considered by experimenters in the field of the deposition of metals, and efforts should be made to classify the results which have already been obtained. The peculiar and simple method by which Mr. Betts obtains the lead in a solid and dense structure—by means of a reducing action, practically accomplished by the addition of gelatine and glue—is certainly encouraging.

## NOTICE TO OUR CORRESPONDENTS.

A package of our mail was lost in transit last month. If any of our correspondents addressed us on any subject, and have not heard from us, will they please communicate with us again, as the letter may have been among those lost.

Electrochemical Industry.

## THE INTERNATIONAL ELECTRICAL CONGRESS OF ST. LOUIS.

September 12-17, 1904.

According to the present indications, the International Electrical Congress to be in session at St. Louis, September 12-17, 1904, will be one of the most successful that has yet been held, both with respect to the number of adhesions and to the value of the transactions.

Up to date about 3550 circular letters of invitations to join the Congress have been issued to persons or associations in North America. From these, 875 postal-card acceptances of membership have been received. About 350 similar circular letters of invitation have been recently sent to other countries. It is intended to issue in all about 5000 invitation circular letters in American, and about 6000 in foreign countries. It is expected that many persons will join the Congress, both in America and abroad, who do not expect to attend the sessions in St. Louis, in order to secure a copy of the Transactions, which will form one, and, perhaps, two, large octavo volumes. Collection of fees has commenced, and upon receipt of a fee the member will be forwarded a certificate of membership, a reproduction of which is shown herewith. The certificate is 8½ inches by 11 inches in size (21.5 cms. × 28 cms.) and printed on heavy paper, and is signed by the president, secretary and treasurer.

Recently 280 special letters of invitation have been issued on behalf of the committee of organization to prominent electricians and electrical engineers, signed by the president and the general secretary of the committee, requesting papers for the Congress in the various sections. Of these, 146 have been sent to foreign authors, and 134 to American authors. There has not been time to receive replies from more than a few foreign authors, but twenty-one acceptances have, up to date, been received from abroad, and forty-six acceptances from North America. Sixty-seven papers are thus already promised for the Congress, and the number is steadily increasing. A considerable number of invitations to contribute papers have yet to be issued. It is hoped that the Congress will convene with a full programme in each section, and that at least half of the papers may be from foreign countries. According to the plans of the committee, papers for the Congress programme are specially invited, but papers voluntarily offered will be submitted to the officers of the sections to which the papers belong, and may be included in the programme by invitation at their request, if the subjects are desirable, and if the schedule alloted to each section will permit, it being the desire of the section officers to secure and offer the best possible programme and presentation.

Among those foreign electrochemists who have already accepted the invitation to present papers are Prof. W. Borchers, Aachen; Dr. F. Dolezalek, Berlin; Dr. Hans Goldschmidt, Essen; Prof. F. Haber, Karlsruhe, and Mr. J. Swinburne, London.

Petitions from the Congress committee of organization, and from the president of the American Institute of Electrical Engineers, have been filed with the Department of State at Washington, through the Department of Commerce and Labor, and the National Bureau of Standards, urging that the various foreign governments should be invited to appoint official delegates to the Congress. The lists of such delegates to be invited is in accordance with the lists allotted to the various countries at the Paris Congress of 1900, and the Chicago Congress of 1893. Including the United States, the lists comprise fifty-six official delegates. Information has been received that these petitions have been granted, and that the State Department, on the 17th of December, 1903, instructed the diplomatic officers of the United States abroad to extend an invitation to foreign countries to be represented at the Congress by delegates.

Arrangements are being made with a view to perfecting plans of co-operation between the Congress and electrical societies and associations in various parts of the world. Invitations have already been extended to the Congress members to visit places of electrical interest on the journey to or from St. Louis.

The committee of organization of the Congress consists of Elihu Thomson, president; A. E. Kennelly, general secretary; W. D. Weaver, treasurer; Bion J. Arnold, vice-president and chairman of the executive committee; C. F. Scott, Dr. S. W. Stratton, Prof. H. S. Carhart and Prof. W. E. Goldsbrough, vice-presidents.

A list of the officers of the various sections has already been published on page 560 of our issue of December, 1903. All communications should be addressed to the general secretary, Dr. A. E. Kennelly, Harvard University, Cambridge, Mass.

## THE ELECTRIC CLUB JOURNAL.

The Electric Club of Pittsburg, Pa., which was organized on March 19, 1902, and consists principally of apprentices and engineers of the Westinghouse Electric & Manufacturing Co., announces that it is now to enter a new field by issuing a monthly publication of its own, under the title, *The Electric Club Journal*. The first issue will appear on February 1.

## ELECTROMETALLURGY OF IRON.

We are informed that a commission has been appointed by the Canadian government for the purpose of investigating the different electric furnace methods in use in various iron and steel plants in Europe. This committee consists of the following gentlemen: Dr. Eugene Haanel, Supt. of Mines in Canada; Mr. C. E. Brown, electrical engineer, and an English steel expert. Dr. Haanel and Mr. Brown sailed from New York on January 23 for Europe. The commission will visit France, Italy and Sweden, and it is likely that it will be four months or more before the commission returns to the Dominion.

## ACID-PROOF RUBBER GOODS.

The following notes on acid-proof rubber goods are taken from a recent consular report. According to Dr. C. O. Weber, pure vulcanized rubber is very little acted upon by acids; the less pure the smaller the capability of the rubber to absorb aqueous liquids. It is well known that Para rubber on prolonged immersion in water will eventually be found to have absorbed from 24 to 28 per cent of water. On testing different brands of rubber, it is found that they exhibit great differences in their capability of absorbing water, and that this variation very closely follows the percentage of resinous matter contained in the various brands. This should not, however, be taken to amount to a recommendation to use, in the manufacture of acid-proof goods, resinous, low-class rubbers only. This would in so far be a mistake, as the rubber substance proper of the low-class rubbers is itself much more readily affected by the above-named acids than the high-class rubbers, notably Para. But this observation of the decreased capability of low-grade rubbers to absorb water clearly indicates the line to be followed in the production of acid-proof goods. It will, indeed, be found that mixings of Para with resins show a very much decreased capability of water absorption, but there are, as a matter of fact, several substances which prove far more efficient in this respect than the resins, and which at the same time are less objectionable for compounding purposes than the latter. These substances are paraffin wax, ceresin, mixtures of paraffin wax and heavy mineral oils, and, better still, the products obtainable by treating paraffin wax with sulphur.

## ON THE MICROSTRUCTURE OF METALS AND ALLOYS.

BY WILLIAM CAMPBELL.

Since the application of the microscope to the study of metals and alloys, our knowledge of their constitution has made rapid progress.

When a metal cools down from the liquid state and reaches its freezing point, it begins to crystallize out in the form of dendrites or skeleton crystals. The more rapidly it passes its temperature of solidification, the more rapid will be its crystallization, and the smaller will be its resulting structure. This dendritic structure is common to all metals, though each has its characteristic form. The crystals of lead in the Pattinson process, those of bismuth in a crust of that metal, the stars of antimony ingots are too well known to need more than mention here.

Fig. 1, magnified 35 diameters, shows the surface structure of aluminium cast in the form of a thin sheet on a cold stone

FIG. 1.—SURFACE OF CAST ALUMINIUM.

slab. It consists of dendrites with two main axes at right angles, from each of which grow out club-like secondaries.

Dendrites grow more freely in impure than in pure metals, for the presence of a more fusible mother-liquor allows of freer growth. In a very pure metal the surface is usually smooth, but etching reveals the granular crystallization of which dendrites are merely the framework.

Even electrolytically deposited metals may be crystalline. Fig. 2, magnified 35 diameters, shows a section of electro-copper fresh from the vat. It has been polished and etched with nitric acid. The difference in orientation of the grains or crystals is marked. Fig. 3, magnified 20 diameters, shows some crystals of electro-silver. Their crystalline habit is marked. On the other hand, electro-nickel and electro-iron have an onion-like structure due to concentric growth, and so far no crystals have been observed.

The crystalline structure of metals has been carefully worked out by Ewing and Rosenhain[1], who also observed the effects of strain, and of annealing. Within the elastic limit no change is noticed. As soon as deformation takes place, slip-lines are seen in the grains or crystals. They are more or less straight and parallel in each crystal, but are differently oriented in different crystals. Those which first appear are more or less normal to the line of strain, but as the strain increases systems lying in other directions appear. In some metals the slipping apparently takes the form of twinning, like plagioclase felspar.

When the strain is severe, as, for instance, in rolling or hammering, the large crystallization due to initial cooling, is broken down, and a much finer structure results, which is still truly crystalline.

Annealing causes a rearrangement and crystals grow, in some cases to a size larger than the original before hammering, etc. This change in the solid occurs at temperatures far below the melting point. In fact, in the case of lead, tin, etc., it takes place very slowly at normal temperatures.[2]

The effect of strain on the crystalline structure of lead has recently formed the subject of research by Humphrey.[3]

### IRON AND STEEL.

Professor Howe has written a very excellent book on iron, steel and other alloys,[4] which brings our knowledge of the constitution of iron and steel thoroughly up to date.

Iron and carbon form a simple series of alloys above 1100° C., falling into group I. of LeChatelier's classification by cooling curves.[5] In other words, the freezing-point curve consists of two inclined branches meeting at the eutectic point. In the curve, branch A B corresponds to the falling out of solution or freezing out of the crystals of iron. Branch D B corresponds to the separating out of graphite, while the horizontal branch a B C corresponds to the solidification of the mother-liquor, or eutectic of iron and graphite. The B D graphite is kish.

Fig. 9, magnified 35 diameters, shows an alloy occurring between a and B. It consists of dendrites of iron, surrounded by a matrix consisting of alternate laminæ of iron and graphite. The dendrites began to crystallize out when the molten alloy reached the temperature of the curve A B. They continued to grow and enrich the mother-liquor (with respect to carbon) till the later had a composition of B at a temperature just above 1100° C. The mother-liquor then solidified as alternate laminæ of iron and graphite.

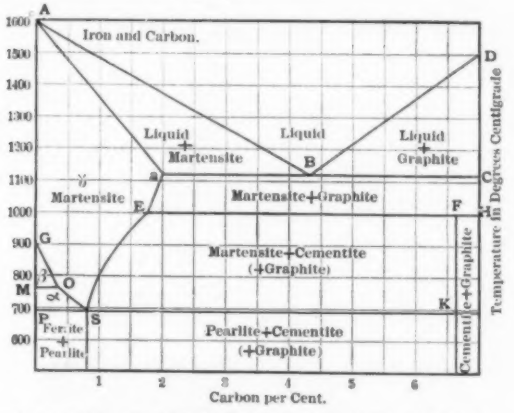


DIAGRAM OF ALLOYS OF IRON AND CARBON.

As Rooseboom has shown, the line Aa gives the composition of the dendrites as they fall out of solution. Iron becomes saturated with carbon at a, or about 2 per cent. In other words, the concentration of the solid solution of carbon in iron at 1100° C. is about 2 per cent.

This solid solution is called martensite. As the temperature falls to 1000° C. the solid solution is reduced to 1.8 per cent, and more graphite separates out.

Now, in the region a C H E we have martensite and graphite in equilibrium, but as the temperature falls below E H, or 1000° C., this is no longer so. A reaction takes place.

Martensite + graphite = cementite, and $Fe_3C$ is formed. Thus, below 1000° C. martensite and cementite are in equilibrium. As a matter of fact, the reaction between martensite and graphite is so slow and so difficult that it rarely goes more than a little way. The reverse or the splitting up of cementite into graphite and martensite readily takes place, when a white iron is heated to above 1000° C., though Tiemann has shown that the presence of some silicon is necessary.

Now, suppose we have a liquid of the composition a to B,

[1]Phil. Trans., Royal Society, London, 193, p. 353; 195, p. 279.

[2]Mineral Industry, XI., 1903, p. 662.
[3]Phil. Trans., Royal Society, London, 200, p. 225.
[4]Sauveur and Whiting, Boston, 1903.
[5]See J. Franklin Institute, 1902, "On Structure of Metals and Alloys."

and it cools past A B, dendrites of iron fall out. But if the cooling be so fast that it reaches the region where martensite and graphite are no longer in equilibrium, before it solidifies, then we have martensite and cementite formed.

Fig. 10 × 35, shows a section of washed metal. It contains dendrites of iron as before, set in a matrix. But this matrix consists of alternate laminæ of iron and cementite ($Fe_3C$). The carbon runs 3.5 per cent. On heating this up to above 1000° C., we should have graphite formed.

Thus, gray irons have solidified at a temperature in which graphite and martensite were in equilibrium, and as these two react with difficulty we continue to have graphite. On the other hand white cast irons possess a matrix which solidified for the most part at a temperature where martensite and cementite were in equilibrium, and so we have no graphite present.

And now we must say a few words about those alloys of our series lying between G and E per cent C., or low, medium and high carbon steels. Below Aa we have a uniform solid solution of, say, 1.8 per cent carbon in iron. This solid solution acts just like a liquid solution when it cools, and we have solids crystallizing out. Hence, we get a second V-shaped curve, G O S E, consisting of two inclined branches, G O S and S E meeting in the point S (or 0.8 per cent carbon) and the horizontal branch P S K.

G O S corresponds to the falling out of solution of the constituent ferrite or pure iron; E S corresponds to the falling out of cementite or $Fe_3C$, while P S K corresponds to the change of the mother-solid or *eutectoid* from a solid solution of 0.8 per cent C. into alternate laminæ of pure iron or ferrite and cementite ($Fe_3C$). This eutectoid is pearlite, and the change takes place at the recalescence point, just below 700° C.

Now, a steel with less than 0.80 or S per cent carbon would, when slowly cooled, consist of ferrite and pearlite. The ferrite would have separated out along the curve G O S. A steel with 0.80 per cent carbon, consists of pearlite alone, which forms at the temperature P S K; while a steel with more than 0.80 carbon consists of pearlite and cementite ($Fe_3C$), which separated out along S E.

Now, iron has three forms, $\alpha$, $\beta$ and $\gamma$. In pure iron $\alpha$ exists up to the temperature M, about 760° C. $\beta$ exists between M and G (900° C.), while $\gamma$ exists at temperatures

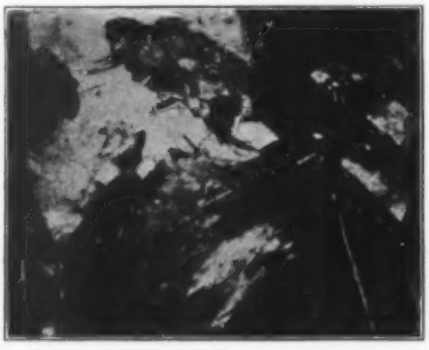

FIG. 2.—ELECTROLYTIC COPPER, POLISHED AND EDGED.

above 900° C. In steel, iron is in $\gamma$ form when it exists above G O S in martensite. In the area G O M it occurs as $\beta$, while below M O S it is in the $\alpha$ form. Thus, the line G O represents the separation of $\beta$ iron from the solid solution martensite, the line O S represents the separation of $\alpha$ iron from martensite, while the line M O denotes the change of $\beta$ into $\alpha$ iron with fall of temperature.

Figs. 4 to 8 represent the series of steels found in class G to E per cent carbon. Fig. 4 × 110 diameters, shows a steel containing 0.035 per cent C. It consists of large grains of ferrite with patches of a dark material, which, under a higher magnification, is seen to be pearlite. The steel was heated to 1100° C. and slowly cooled.

Fig. 5 × 110 diameters, contains 0.22 per cent C. The ferrite areas have decreased and the pearlite has increased with the increase in carbon. This steel was heated to 1100° C. and slowly cooled.

Fig. 6 × 110 diameters, shows a steel containing 0.37 per cent C., heated to 1200° C. and slowly cooled. The pearlite areas are now continuous and contain the patches of ferrite.

Fig. 7 × 35 diameters, shows a steel with 0.5 per cent carbon. The ferrite is in the form of veins and cell walls round the pearlite areas. The shape of these grains of pearlite is due to the fact that they are pseudomorphs of martensite. This steel was heated to over 1300° C., and the grains are coarse. The size of grain varies as the temperature to which the steel

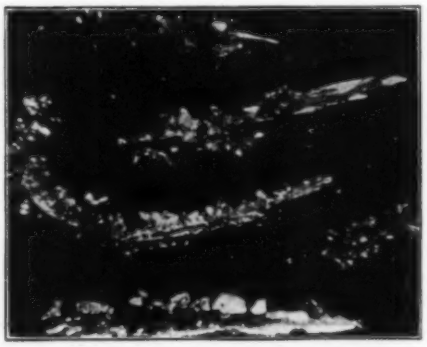

FIG. 3.—CRYSTALS OF ELECTROLYTIC SILVER.

has been heated above the critical point, P S K. With further increase in carbon the ferrite disappears at 0.8 per cent C, and we have the steel consisting of pearlite alone.

Above this point we have steels containing an excess of cementite ($Fe_3C$), which separates out along the line E S, while the residual martensite changes to pearlite on reaching the temperature S K as before.

Fig. 8 × 110 diameters, shows a steel containing 1.17 per cent C heated to 1200° C. and slowly cooled. It consists of white bands and threads of cementite set in a matrix of pearlite, just as below 0.8 per cent C. we had ferrite in pearlite.

Returning now to our cast-iron, in Fig. 9 the dendrites of martensite are white, because they have been only lightly etched. On deeper etching they are seen to be built up of two constituents—pearlite and an excess of cementite. What happened was as follows. The dendrites of martensite on passing the temperature E H become supersaturated with cementite, which separates out from the mother-solid, whose composition follows the line S E as the temperature falls till at just under 700° C. it has the composition of S (0.8 per cent C). At this temperature, the recalescence point, the residual martensite changes over to pearlite. The same holds good for the white iron in Fig. 10.

From the above we see that low, medium, high carbon steel and gray or white cast-iron form one unbroken series, and the difference between white and gray iron is merely one of equilibrium at the solidification point of the mother-liquor, whether graphite (gray) or cementite (white) is in equilibrium with the martensite.

In steel the structure is of very great importance. All steels in the martensitic state, i. e., those which have been quenched from temperatures above the line P S K are hard. There is still great discussion as to whether hardening is due to the existence of $\gamma$ iron or the retention of martensite by quenching. Medium carbon steel quenched from within the area P S O G is hard, apparently because the cementite is retained

in solution with the ferrite, as the solid solution martensite, and not as a free constituent of the eutectoid pearlite.

On the other hand, it is said that pure iron, when retained in the $\gamma$ state is hard. Perhaps both the allotropists and the carbonists are right, and hardening is due both to $\gamma$ iron and to carbon or cementite in solid solution.

The size of structure is also important, for the strength depends to a great degree on the size of grain. The size of grain is that of the martensite, and the higher the temperature above P S K, to which the steel is heated, the coarser the grain, till we reach A a C, when melting begins.

If steel is worked, as, for instance, by rolling or hammering, crystallization only takes place after this has ceased. Hence, we have had much research on finishing temperatures, and such processes as the Kennedy-Morrison[6].

Much work[7] has been done recently on the structure of iron and steel, and many very important facts have been brought to light. The identity of sorbite as the transition of martensite into pearlite is established[8].

Stead and Richards[9] in a paper on sorbitic steel rails give a simple method for the production of sorbite in steel. The usual method has been to reheat and oil-harden, or to reheat to dull red after quenching in water. They quench the heads of rails (after sawing to length) to below Ar1, and then allow the residual heat in the rails to temper them. They find that a normal rail of 37 tons tenacity has a strength of 45 tons after being made sorbitic, without any loss in contraction of area.

They point out that in all structural steels which have to undergo friction, percussion or vibration, the pearlite ought to be replaced by sorbite.

Stansfield[10] points out that the burnt structure of very much

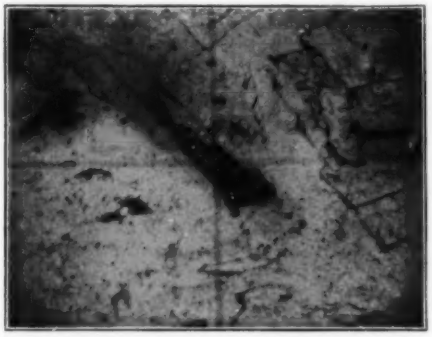

FIG. 4.—0.035 PER CENT C. × 110. FERRITE AND PEARLITE.

overheated steel is caused by the partial melting due to heating the steel to temperatures above Aa. He recognizes the following stages:

I. Overheating (below the point of incipient fusion).

II. Partial melting or burning.

(a) Merely producing segregation of carbon in the joints.

(b) Accompanied with liquation and producing flaws.

(c) Further liquation and oxidation in the flaws.

I. Steel that has been merely overheated can be completely restored by reheating just above its highest recalescence point and allowing to cool.

II. Steel in the stage (a) can be restored by suitable annealing; in stage (b) forging would also be needed; and in stage (c) it would be restored with great difficulty, if at all.

The heat treatment of steel under conditions of steel works practice has been studied by Campion[11]. He finds that steel containing 0.20 carbon has three critical points,

| Ar3 | Ar2 | Ar1 |
|---|---|---|
| 798° C. | 730° C. | 670° C. |

[6]Mineral Industry, IX., Iron Age, Dec. 20, 1900.
[7]Mineral Industry, XI., 1903, p. 663 et seq.
[8]J. Iron and Steel Institute, 1902, I., p. 120 et seq. and discussion.
[9]Journal Iron and Steel Inst., 1903, Sept.
[10]Journal Iron and Steel Inst., 1903, II.
[11]Journal Iron and Steel Inst., 1903, I., p. 378.

Small rolled sections can be heated to a maximum temperature of 850° C. without serious injury. Slow-cooling from 800° C., or more, to Ar1 tends to produce brittleness, however. In larger sections 800° C. ought to be the maximum temperature above which the metal ought not to be heated if it has to stand sudden shock. In the case of large forged bars 700° to 850 C. are the limits of temperature at which such material should be treated. Between 500° and 650° C. brittleness is produced, especially when slow cooling follows.

Steel containing 0.30 to 0.40 carbon shows two critical points:

| Ar3.2 | Ar1 |
|---|---|
| 725° C. | 680° C. |

and when in small, rolled sections, it is improved for resisting shock after heating to 650° to 800° C. The rate of cooling

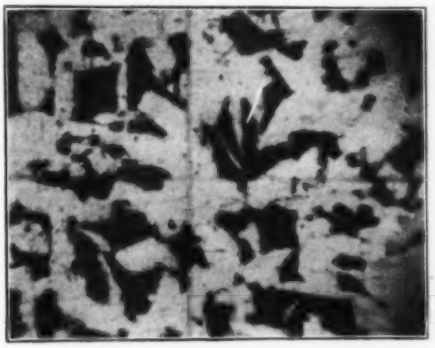

FIG. 5.—0.22 PER CENT C. × 110. FERRITE AND PEARLITE.

does not affect the result. No brittleness results from heating between 500° and 600° C. For large rolled bars the best temperature is 700° to 800° C. A brittleness develops at 900° and higher. Slow cooling is apparently not very harmful. In the case of forged bars, 6 inches diameter, the best temperature is between 700° and 760° C.

Steel containing 0.50 to 0.60 carbon has one critical point, Ar3.2.1 at 673° C. Small rolled bars give the best results after heating to 700° to 800° C., with slow or rapid cooling. The same temperature answers for larger rolled bars, but for forged material the temperature ought to be slightly lower.

Steel containing 0.60 to 0.70 carbon has Ar3.2.1 at 670° C. Small rolled bars gave best bending tests after heating to 600°

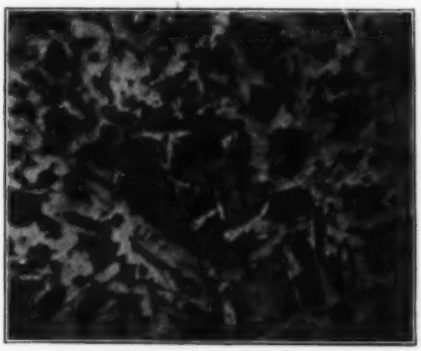

FIG. 6.—0.37 PER CENT C. × 110. FERRITE AND PEARLITE.

to 700° C. Thicker bars at 720° C. Rate of cooling is of small importance. Six-inch forged bars require a temperature of 700° to 760° C., while heating large bars of this carbon content to over 850° C. produces brittleness.

Alloy and special steels are now receiving great attention. Léon Guillet has carefully worked out the structure[12] of nickel

[12]Bull. de la Soc. d'Enc., May 31, 1903.

steels, while Colby is working out their physical properties, etc.

Tungsten steel is being studied by Hadfield[12] and others, while chrome and other rarer steels are being experimented with.

One of the great effects of alloying other metals with steel is in general to lower the critical points.

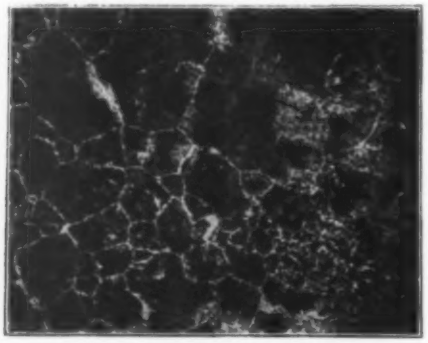

FIG. 7.—0.5 PER CENT C. × 35. VEINS AND WALLS OF FERRITE ROUND PEARLITE AREAS.

The influence of sulphur and manganese on steel has been studied by Arnold and Waterhouse[14], who find that sulphide of iron is very injurious to steel, while sulphide of manganese is comparatively harmless. Iron sulphide is relatively fusible, has a high coefficient of contraction, and tends to form cell walls round the ferrite. On the other hand, sulphide of manganese is much less fusible, segregates while the iron is at a high temperature, and collects in the form of rough globules, seldom of meshes.

Manganese retards the segregation of iron and hardenite, and the so-called pearlite of a normally cooled manganese steel is really a mixture of granular pearlite and unsegregated ferrite. Very slow cooling allows the complete separation of the ferrite in a manganiferous steel, but such slow cooling injures the steel by lowering the maximum load and the reduction of area.

FIG. 8.—1.17 PER CENT C. × 110. CEMENTITE AND PEARLITE.

Le Chatelier and Ziegler[15] have done some very interesting research upon sulphide of iron, its properties and its conditions in iron. They found that commercial sulphide of iron ($FeS_{0.8}$) contained three constituents:

1. Some yellow grains constituting the bulk of the sample. They are sulphide of iron.

2. Brilliant parts having a metallic lustre much more pronounced than the sulphide, and a white color very similar to that of iron. This constituent is metallic iron.

3. Finally, between the yellow grains, occurs a eutectic of sulphide and oxide of iron.

The sulphide melts at 950° C. On the other hand, an alloy of manganese and 0.14 per cent sulphur shows dendrites of sulphide set in a matrix of manganese. Therefore, sulphide of manganese crystallizes out before the manganese and therefore is less fusible than iron.

Boudouard[16] has determined the points of allotropic changes of iron and its alloys by the measurement of the variations in the electric resistance. His work shows that the phenomena of the electric resistance of iron and its alloys in functions of the temperature are perfectly reversible outside the limits of temperature in which the allotropic changes occur. In the region of the critical points, the difference between the heating and the cooling curves of carbon steels is greater the higher the percentage of carbon. Steels containing chromium, manganese, tungsten, etc., show distinctive features similar to those of steels with more than one per cent carbon.

In the case of carbon steels the electric resistance increases with the carbon content. The addition of chromium and of tungsten increases the resistance sensibly in the ratio of 1 to 2. This ratio of increase is not maintained at high temperatures, but the resistance becomes about equal to that of carbon steels. Manganese at ordinary temperatures increases the resistance two or three times, while nickel produces an even

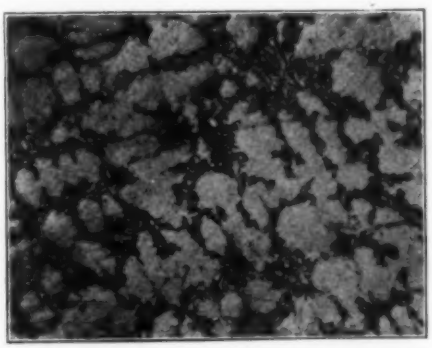

FIG. 9.—GRAY CAST IRON × 35. IRON CRYSTALS IN GRAPHITE GROUND MASS.

greater resistance. However, in both cases the ratio of increase falls off at higher temperatures.

### Alloys.

A remarkably good piece of work on the alloys of copper and tin has been published by Heycock and Neville[17]. Their photographs remind one of Osmond's on steel. In a diagram they explain the constitution of the whole series of alloys, using Rooseboom's theory of solid solutions.

There is no doubt that in the case of the bronzes, brasses, aluminium copper alloys, and others, that we have to deal with changes in the solid. For instance, between 80 and 90 per cent copper in the Cu-Al series, the alloys set as a whole in the form of solid solutions directly akin to martensite. At a low temperature $AlCu_3$, or AlCu (?) separate out, whichever happens to be in excess, just as did ferrite or cementite in steel. Finally, the mother-solid changes from a solid solution into a eutectoid of alternate laminæ of the two compounds.

In the case of copper and $Cu_4Sn$ the case is rather more complicated, for part of the copper separates out from the liquid alloy, but the change in the solid is the same[18].

Boudouard has worked out the constitution of the alloys of magnesium with aluminium[19] cadmium[20] and copper[21].

[12] Iron and Steel Inst., Sept., 1903.
[14] Journal Iron and Steel Institute, 1903., I., p. 136.
[15] Bull. de la Soc. d'Enc., Sept., 1902.
[16] Journal Iron and Steel Institute, 1903, I., 299.
[17] Phil. Trans., Royal Society, 202, p. 1-49.
[18] Proc. Inst. Mech. Engineers, London, 1901. Appendix to Alloys Research Committee Report.
[19] Bull. de la Soc. d'Enc., Dec., 1901.
[20] Bull. de la Soc. d'Enc., Aug., 1902.
[21] Bull. de la Soc. d'Enc., Aug., 1903.
See also Comptes Rendus, 1901 and 1902.

He finds that $AlMg_2$, AlMg, and $Al_2Mg$ can be distinguished. The first two are shown in the freezing-point curves. In the case of the Cu-Mg alloys, he has isolated $CuMg_2$, CuMg and $Cu_2Mg$, the freezing-point curve giving maxima for these alloys.

The Société d'Encouragement pour l'Industrie Nationale has published a volume entitled "Contributions à l'Etude des Alliages." It contains the researches undertaken by the committee on alloys of the Society. It has two papers of great interest, viz., "Microscopic Study of Metallic Alloys," by Charpy and Osmond's great paper on steel.

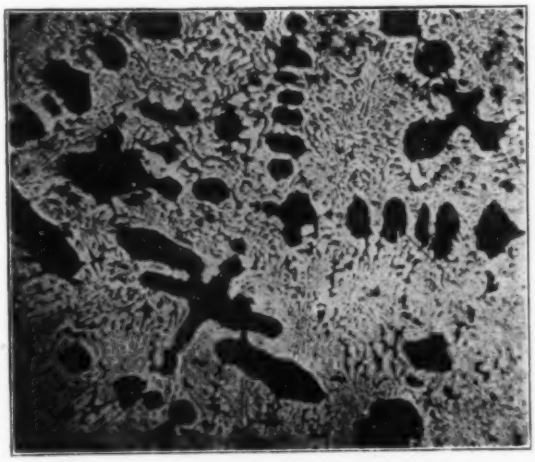

FIG. 10.—WASHED METAL. (WHITE CAST IRON, 3.5 PER CENT C.) IRON CRYSTALS IN A GROUND MASS OF CEMENTITE AND IRON.

In the near future we are to have the last report of the Alloys Research Committee, Mechanical Engineers London, which will finish up the late Sir William Roberts-Austen's work.

Stead and Osmond's book on iron and steel from the point of view of microstructure, etc., will be out very shortly. If it equals their past work, it will be unrivalled, for they are unquestionably two of the foremost men on the subject to-day. It is due to such men that we are beginning to be impressed with the fact that chemical composition is not everything, for, unless our structure be good, the best of materials will not make our finished product anything but a very medium article.

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## ELECTROMETALLURGY OF GOLD IN SOUTH AFRICA—1897 TO 1899.

The Transvaal is the classical country of the metallurgy of gold. The extremely interesting volume II. of the Proceedings of the *Chemical and Metallurgical Society of South Africa*, which has just been published, covering the time from February, 1897, to September, 1899, contains an enormous amount of information on gold metallurgy. In the following notes we give abstracts of some papers which we believe to be of special interest to our readers. As an introduction we give a part of Mr. CHARLES BUTTERS' presidential address.

### METTALLURGY OF GOLD.

Mr. Butters gave a concise review of the development of the metallurgy of gold. The occurence of gold in placers, and the ease with which the bulk of it was recovered by washing; later, the crushing of quartz in the battery and the winning of the fine particles by the beautiful process of amalgamation, were all so simple that for many years there was really no metallurgy of gold. Gold miners became educated only in the system of collecting free gold for the reason that the bulk of the production of gold was, and is, by amalgamation, and only such ores as give up their gold freely by simply crushing, were sought for and worked to any extent. The process of collecting such gold was one of concentration by means of amalgamation, and as the concentration was carried further another product was the result, being the concentrated pyrites of the value of from three to five ounces of gold per ton. Now, to obtain this gold, or a higher percentage of it than could be extracted by further crushing, certain and many processes were studied. This was most practically worked out by Plattner with his chlorination process, and up to some fifteen years ago amalgamation and chlorination were almost the only practicable means in use for winning gold in the gold mines of the world.

The idea of rehandling the whole of the products after concentration had been resorted to came almost in direct opposition to the recognized methods of winning any metal. In the recovery of all metals successive concentration is the method of procedure, and even to-day the metallurgists of Germany are very much averse to agreeing to the fact that it is not the best way of finally treating all the stuff which has been crushed. It has always been more or less known that large losses of gold take place in the pulp by concentration, but as these sands and slimes were usually allowed to be washed away in rivers the loss went unnoticed until, in the Transvaal, on account of its topographical condition, the slimes and sands were necessarily retained or conserved in dams. These accumulations being assayed and valued, showed plainly that something must be done to obtain their contained value. Concentration having reached its limits, another form of concentration was resorted to by the chemists in the shape of the introduction of the solution methods. Of these methods brought forward by various chemists, those of dissolving in cyanide and chlorine, are the only ones in effective use on the Witwatersrand to-day.

There has been a great deal of study given to the use of chlorine as a dissolving agent, but its use is very limited in comparison with that very easily handled solvent, cyanide, so that the author is prepared to state that cyanide is slowly but surely displacing chlorine on the Witwatersrand for all purposes. He has no doubt that upon these fields eventually the use of chlorine will be discontinued; and, having been among the first to be connected with the introduction of the chlorination process in South Africa, he has rather jealously guarded the interests of chlorine as a solvent. He admits now that, given equal preparation of material for the use of the solvent, the same percentage of solution of precious metal in the materials treated can be obtained as well with cyanide as with chlorine. And with the application of recent methods for the recovery of the gold from these solutions, as high a percentage of extraction can be obtained by the cyanide as with the chlorination process.

Continuing the work of recovery by solutions, we get first in dissolving the gold in the solution a new material of less value per ton than it was in the material to be treated. Generally speaking, it may be said that for the sand treated, it takes from a ton and a half of solution to dissolve the gold, while in slimes, from four to six tons of solution is used to dissolve and wash out the gold, and it is in connection with the solution, varying in value from ½ dwt. up to 10 dwts., that the metallurgical chemist is presented with the last problem in concentration which he must apply to his operations—viz., the concentration of gold from the liquid. For this operation we have at present only two processes acting successfully—that of zinc precipitation and that of electric precipitation on lead foil or shavings. The chemicals and substances that could be used as solvents in the work of dissolving the gold from the material are not more varied than the number of precipitation processes which may be employed for its ultimate recovery or concentration from the liquid used as a carrier; but, of all solvents, cyanide has proved itself the most generally useful and serviceable.

### Zinc-Copper Couple for Gold Precipitation from Cyanides.

In a paper on this subject Mr. L. Ehrmann points out that the zinc process has been in great favor on account of its simplicity, and very successful in general practice; but there are cases where it has proved too slow, or the percentage of gold extracted from the solution too low. This is the reason why, principally with poor solutions, the electrolytic process is used, when the simpler method of zinc boxes seems ineffective. There is no doubt that electrolytic processes for extraction of metals from solutions are, scientifically speaking, the best, as they can be regulated; but they require more care and technical knowledge than the ordinary zinc process. An electrolytic process can be made more simple, if electrolysis of the solution is produced in the zinc boxes, by contact of two different metals, instead of being produced by an external source of electricity. The question of elevation of temperature of the solution, so as to facilitate the chemical reactions to make them more complete and rapid, is also of extreme importance.

The author has made experiments in which he investigated the effect of an increase in temperature and compared the effect of zinc with that of a zinc-copper couple. In the first case zinc shavings were used in the ordinary way, the zinc being commercial zinc bought in Johannesburg (not chemically pure zinc; this is important, since chemically pure zinc is known to have a very small precipitating effect); in the second case he used zinc shavings more or less coated with a very thin film of copper. The zinc coated with copper he calls a zinc-copper couple. The zinc is, of course, only partially coated.

His experiments show that a zinc-copper couple gives better results than zinc shavings alone, and that an increase of temperature has a very beneficial effect, since fresh zinc and a zinc-copper couple precipitate as much gold by hot treatment (at 175° F.) in two hours, as by cold treatment in twenty-four hours. He suggests to use the zinc-copper couple instead of zinc shavings, and to heat the solution to 175° F.

In the discussion Mr. C. Butters remarked that in practice, where there are a thousand tons of liquid handled in a day, it is practically impossible to raise the temperature to 175° F.; neither would it be economical, since coal is very expensive in the Transvaal. Several of the engineers who took part in the discussion remarked that they had not observed any difference in the precipitation in summer and in winter, while Mr. G. T. M. McBride stated that he had noticed he obtained a little better precipitation in summer than in winter, but the difference was very slight. (Some very interesting data on this point are given below under the heading, Influence of temperature on the cyanide process.) Mr. J. R. Williams has found the more impure the zinc, the better it is for the purpose of precipitation. He thinks the use of zinc-copper couple to be superfluous; he has not met with a single case of bad precipitation which cannot be successfully overcome by the addition of a little lead salt of any form (like lead acetate) which is soluble in caustic alkali or in cyanide of potassium. To explain the action of the lead salt, he offers two hypotheses: The one that lead is precipitated in a spongy form on the zinc, thus forming a very good couple, the other being based on the supposition of catalytic action.

### Bi-Products from Cyanide Works.

From a paper by Mr. Charles Butters, the following notes on bi-products from cyanide works are taken. The bi-products that are obtained from the cyanide works are very much less in the case of fresh unoxidized ores than from acid or partly oxidized ores. Where the ores crushed have been exposed to atmospheric influences, and are partly weathered, the products of incomplete decomposition of the iron compounds always introduce a series of complications in the solution and precipitation of the gold that increases the amount of bi-products, whether the gold so dissolved is precipitated by chemical or electrical agency. In the case of the unweathered pyritic ore, or of perfectly oxidized ore, a solution is obtained comparatively free of iron salts, but in the case of a partially oxidized ore the ferrous and ferric salts produced form, with cyanide and alkali, ferro-cyanides and ferrous and ferric hydrates. These diminish the efficiency, more especially of the chemical precipitating agency, and also increase the amount of sludge obtained from the electrical precipitation boxes.

In the case of these acid ores a comparatively large amount of lime is needed, which, going into solution in the shape of hydrate, carbonate, and sulphate of lime, crystallizes out in the zinc box, and in the electrical precipitating box upon almost everything that it comes in contact with, more or less destroying the precipitating surfaces. This is a serious difficulty in the treatment of acid slimes. The surfaces of the lead cathode are almost completely covered after a few weeks by these comparatively insoluble lime salts, which gradually slip off the lead surfaces. By carrying down gold they tend to enrich the precipitates in the bottom of the boxes, as well as the floating precipitates which pass through the boxes and out into the sump.

In zinc precipitation everything that accumulates in the box in the way of slime is taken as the main clean-up. The particles which flow away from the box in mechanical suspension in the form of insoluble complex cyanides and hydrates, clayey matter, insoluble humus which has been precipitated from humic acid, and, in fact, any flocculent precipitates that may float through the box, will always carry gold along with them, which may be partly deposited in the sump. Hence, one might properly say the only bi-products produced directly from the zinc precipitation boxes, outside of the products resulting from the treatment of zinc slimes, are the precipitates obtained from either the settlement of the precipitated liquors, or the precipitate obtained by filtration of all the liquids after passing through the zinc box.

Under ordinary conditions, in a well-conducted cyanide works treating fresh ores, filtration of the precipitated solutions merely to obtain the floating matter from the zinc boxes would not pay, but where acid ores are treated, the precipitated sludge obtained from the sumps is of sufficient importance to warrant its careful collection. This precipitate varies in value from 1 up to 20 ounces to the ton. Precipitates so obtained from the Simmer and Jack cyanide works, where fresh pyritic ores have been treated, assayed 2 ounces 18 dwts. During the precipitation of rich solutions, running from 5 ounces to 8 ounces to the ton, flocculent precipitates assaying 14 ounces per ton, and composed of zinc cyanide and zinc ferro cyanide, insoluble in the dilute liquor used, were carried over into the sumps. A skimming taken from the top of the treated tank partly mixed with exhausted residue, gave an assay of 16 dwts. per ton, due mainly to finely-divided precipitated gold, which had been pumped back. Black skimmings of organic matter, resulting in the same way from the filtering through sand of precipitated liquors, gave an assay of 5 dwts. per ton. It is worth the attention of cyanide managers to see that the sumps are regularly cleaned of sludge, which may be dried by pouring into a small enclosure or dam made of tailings in the open air. After two or three weeks this material is dry enough to sample and assay, and in nearly every case will be found rich enough to sell to the smelting works. The gold in precipitates so obtained is not easily soluble in cyanide solutions, unless special preparation is given to their proper oxidation, either by means of preliminary roasting, or long-continued exposure to aeration and agitation with cyanide solution in an agitating vat.

In the Siemens & Halske precipitation boxes the main clean-up is obtained from the melting of the lead cathodes. Whatever else is obtained from the box in the shape of gold, is termed gold from bi-products. The sources of these bi-products are the insoluble compounds of iron and cyanogen. The iron of

the anode oxidizes, forming ferrous hydrate, which partly unites with the cyanide in the solution forming ferrocyanide, from which Prussian blue is derived, and partly undergoes further oxidation to ferric hydrate. Portions of these precipitates settle in the bottoms of the boxes, and a portion floats through them into the sump, where they become by degrees oxidized to the ferric state. This precipitate also adheres to and saturates the sacking which covers the iron plate; when, after long usage, this sacking becomes rotten it is removed and burnt, and the anodes are likewise carefully scaled of oxide. The value of the Prussian blue, of the ashes resulting from the burning of the sacks, and of the scalings of the plates, vary with the care and regularity with which the process has been carried on.

In a sand plant, where all the solutions come filtered clear to the boxes the Prussian blue may be cleaned up for sale every two months, and may contain from 5 to 50 ounces to the ton. The products from the sacks and the plates, which is obtained every one or two years, may have about the same average value as the Prussian blue. The value of these bi-products has averaged, so far, at the Worcester, which is the oldest Siemens & Halske sand plant, about 25 ounces for scalings in 1895, and 21 ounces for scalings in 1896, 21 ounces for Prussian blue in 1895, and 9 ounces for Prussian blue in 1896.

In a slime plant the difficulty of obtaining an absolutely clear liquid for precipitation introduces a certain amount of ore slime which becomes mixed with the Prussian blue, thereby increasing the quantity and decreasing the value of this product. With fresh slimes a clearer liquid and less mud is introduced into the precipitation boxes than with acid slimes, while with mud from imperfect settlements, precipitated lime salts, and the formation of insoluble sulphates and hydrates and complex cyanides, any precipitation process, no matter how perfect, is very much handicapped.

To prevent this state of affairs in the precipitation boxes, the author constructs sand filters to clarify the liquid before precipitation. When a sand and slimes plant are worked together, as at the Bonanza, a large proportion of the solution decanted off from the slimes, can be clarified by passing through the sand vats as a wash. The precipitates which form in the boxes themselves do not have nearly so bad an effect as the introduction of a small amount of finely divided silica or clay. While there may be over 1 ounce to the ton of finely-suspended siliceous slime in the liquid flowing through the box, still this small quantity coats both the anode and cathode with a fine film of non-conducting material, thus preventing the gold from adhering firmly to the cathode, as well as raising the voltage in the box. Hence, the clarification of the solutions, whether from fresh or accumulated slimes, will tend to reduce the amount of bi-products, which must be sold and increase the percentage of gold directly obtained by the melting of the lead strips.

The melting of the Siemens & Halske strips is generally done in a small reverberatory furnace, about 5 feet by 2 feet 6 inches. If this lead is fairly clean and free from siliceous mud and iron salts, a quick, clean melting takes place, and at the end of the operation, a little powdered coal may be spread over the surface of the oxidized bath and the temperature raised to as high a point as possible; afterwards the furnace is allowed to cool down and the lead tapped into moulds. In addition to the clean lead obtained from this melting, which may run from 5 per cent up to 10 per cent in gold, there is obtained a clean liquid slag, which is mostly litharge, or, in the case of dirty lead strips the temperature obtained is not sufficient to slag this, and a pulverulent residue is left in the furnace which is known as "skimmings."

Generally, where it is necessary to make more than one melting for a clean-up, all the skimmings resulting from previous meltings are put into the furnace, and the furnace is brought up to as high a temperature as possible, and the skimmings are sweated of their remaining lead contents. When every drop of lead has been drained from them that can be obtained, the hot skimmings are raked out and allowed to cool. These skimmings are then ground in a Chilian edge-roller mill and screened through a screen of about eight holes to the linear inch, from which two bi-products are obtained, known as "coarse metallics" and "ground skimmings."

The coarse metallics are melted in a pot and yield one or two bars of lead. The lead bars obtained from the melting furnace are then remelted in an iron melting pot, carefully skimmed, and poured into moulds. The skimmings obtained from this melting pot are added to the first lot of the skimmings obtained from the reverberatory furnace. All the lead, whether obtained directly as bars from the reverberatory furnace or from melting the coarse metallics is considered lead bullion, and only the skimmings are known as "bi-products," for the reason that the skimmings must be remelted in a pan furnace before their contents are obtained as lead bullion. Under careful treatment, the amount of gold obtained in the skimmings may be reduced to under 1 per cent. The cupellation of this bullion produces another set of bi-products, amounting to about ¼ per cent, which are known as the "refinery bi-products."

### ELECTROLYTIC PRECIPITATION OF GOLD.

Of the greatest interest are the following remarks of Mr. CHARLES BUTTERS, taken from his presidential valedictory address on the solution of the "slimes problem," relating to the economic treatment of slimes produced by battery crushing. It is, perhaps, superflous to state that Mr. Butters has been most intimately connected with the development of the practical methods representing the solution of this problem. While the final step of precipitating the gold by electrolysis will certainly be of the greatest interest to our readers, yet some brief remarks on the preliminary treatment of the slimes seem here to be in order.

The working of the slimes consists essentially in the coagulation of the slimes in battery water by means of lime, their concentration by spitzkasten, and final settlement in continuous overflow vats or pits. Slimes represent a substance which cannot be leached or through which the solution will not percolate, but which must be washed by decantation. The result is that we have in this case a very large volume of much diluted solution to deal with, and at the same time the slimes contain as moisture nearly their own weight of solution. In order, therefore, that slimes may be economically treated, it is necessary to use a very dilute solution of cyanide, so that too much cyanide may not be lost with the residues when discharged, and that too much may not be decomposed during treatment. In this case one has to work with dilute solutions containing from 0.01 to 0.001 per cent of cyanide, and from 6 to 24 grains of gold per ton. The author speaks very favorably of the system introduced by J. R. Williams, known as "natural settlement" in very large and very deep tanks, together with the system of "double washing," devised in order to reduce the amount of solution passing through the precipitating boxes.

The solution of the gold requires, as well known, the presence of oxygen. This fact renders the treatment of old accumulated slimes much more difficult than that of fresh slimes, for the reason that the former contain a considerable amount of reducing agents. To supply the oxygen required for the dissolving of the gold several methods are possible. A. Caldecott has first introduced a method of introducing atmospheric air through a perforated pipe in the bottom of the vat containing the charge of pulp, while it undergoes agitation. After preliminary oxidation of the pulp has taken place, in order to lessen cyanide consumption, cyanide is added and aeration continues. It was thereby found that the gold dissolved as readily by this method as in the case of fresh slimes. Another method introduced by J. R. Williams is to transfer

the pulp from one vat to another by means of a centrifugal pump. In the passage of the pulp through the pump and pipes more or less air is drawn in through pump and pipe joints and glands, and a certain amount of oxygen is absorbed by the pulp, while the same is undergoing the most perfect agitation in its passage through the centrifugal pump, and afterwards through the pipes. When the stream from the outlet of the pipe falls upon the surface of the pulp remaining in the vat a large amount of air is likewise entangled and carried below the surface by the falling stream, thus causing the very perfect aeration to take place. This method has been found very effective.

The author expresses the opinion that in the future tanks with large diameter, and with great depths will be used without agitators, and the solution of the gold will be done by pumping from one tank to another through a centrifugal pump. The deeper the tank the less moisture or gold-bearing liquid will remain with the pulp, and the fewer times it will be necessary to repump the slime pulp from one vat to another, and the less power will be required per ton of slimes treated. Since the final step of the electrolytic precipitation of the gold is of special interest to our readers, we quote Mr. Butters' remarks on this subject nearly in full, as follows.

Precipitations of metals from solutions present many curious and interesting problems, and one of these is that with the same reagents it is very much more difficult to produce perfect precipitation from a very dilute solution than from a concentrated solution. There are certain chemical and physical laws in connection with this question which are probably not very well understood. For instance, in precipitating gold from a solution of its chloride by means of ferrous sulphate, a fairly rich solution containing 1 to 4 ounces of gold to the ton admits of a very perfect precipitation, if sufficient time is given for settlement, more especially when there are few other metallic salts in solution. A similar solution, but containing only 1 or 2 dwts. to the ton, allows of very imperfect precipitation by ferrous sulphate. This is only one of many illustrations that could be brought forward in connection with chemical precipitation, wherein the results obtained differ widely from what might be expected.

In electrolytic precipitation we have a different set of laws governing the electrodeposition of metals from those which operate in chemical precipitation. In the course of his experiments on the precipitation of dilute cyanide liquors the author tried many methods of precipitating solutions containing 6 grains to 12 grains of gold per ton, but failed completely with such dilute liquor; whereas the same methods acted perfectly on 5 dwts. or 10 dwts. solution. With a dilution of gold down to 6 dwts. per ton, which is about one part in 100,000, it would be natural to think if it was one part in 100,000, or one part in a million, or one part in ten millions, there would not be a very great difference in the resistance of such very minute proportions of dissolved gold to precipitation, whether by electromotive, or by chemical reaction; but the difference between the action of a liquid containing 6 dwts. per ton and one carrying 6 grains per ton is most marked, both in chemical precipitation and in electrolytic deposition.

In general he has found that he could effect the precipitation of the gold in these dilute solutions best, and most economically, by means of electrolysis. He has found that he is more independent in this method of dilution of the gold, and that varying chemical constituents do not have to be looked after quite so closely. It is independent of the amount of cyanide contained in the liquor, and precipitation takes place whether the solution is alkaline or acid.

The principal points in electrolytic precipitation that it is desirable to study, are the amount of current per square foot of anode and cathode, and the time the current is exerted, taken in conjunction with the value of the solution. One of the first points requisite in the electrolytic deposition of gold is that the liquor shall contain no solid matter, that is to say, that it shall be absolutely clear. Otherwise, the great surface which is presented by the cathodes and anodes serves to collect all the fine particles that remain in the liquor; necessarily settlement of any kind upon the metallic surface of the anode or cathode increases the resistance of the precipitating box and results in imperfect adhesion of the particles of gold to the cathode.

This difficulty is easily overcome by passing the liquid before precipitation through a sand filter, or through an intermediate vat of large settling capacity. The liquid which is drawn from fresh slimes is much more readily clarified than the liquid drawn from accumulated slimes. The liquor from the accumulated slimes contains a considerable amount of iron and lime salts in solution, and the settlement of the fine clayey particles is retarded. This may possibly also be due to the organic matter which it contains.

Other substances in the liquid which affect the surface of the cathode, are those salts which are in solution upon entering the box, and are there deposited on the large surfaces exposed, or are electrolysed. Lime which has been used for settlement, and also to neutralize acidity, is in form of carbonate of lime, sulphate of lime, and hydrate of lime. This precipitates partly as carbonate and partly as sulphate upon the cathodes and anodes, more especially on the former, and in the opinion of the author, is precipitated partly by means of the electrolytic current. Then there are the products of the decomposition of the solution itself, which (in the case of iron salts, resulting from the decomposition of the pyrites in the ore) are separated in the form of Prussian blue and hydrates of iron. Then, again, there are the products of the decomposition of the anode plates.

The clearness of the solution depends largely upon the solubility of the anode. The iron plate anode of the Siemens & Halske boxes, with a properly proportioned current, is a very perfect anode, easy to be obtained in any quantity, and is easily manipulated and secured in the boxes. With a current density as low as 0.03 or 0.04 ampere per square foot, very little decomposition of the iron anode takes place. An anode three-sixteenths of an inch in thickness, and with a current density of 0.035 ampere per square foot, should last five years, and possibly much longer. There seems to be a limit of density up to which an iron anode will show very little corrosion, but beyond that point oxidation seems to take place more rapidly than the proportionate rise of current density would indicate. Where the division and tension of the current have been very carefully studied and regulated, very little decomposition of the anode need take place.

With the peroxide of lead anode which was discovered by Mr. Emile Andreoli in the early part of 1895, practically no corrosion of the anode takes place, and the author says he feels confident that its introduction on a large scale would prove satisfactory. (Since this paper of Mr. Butters' was written, this development has, in fact, taken place.—Ed.) With perfectly filtered solutions, and with a peroxide of lead anode, working with fresh slimes, and by watching carefully the amount of lime added to the slimes, there should be very little trouble in maintaining a perfectly clean cathode surface for the plating of the gold.

One point worthy of study by all chemists in connection with the maintenance of a clean anode surface, is to see, either how the lime salts can be prevented from precipitating in the boxes, or if any economical method cannot be devised to reduce the amount in solution. The author thinks it is next to impossible to find any substance that will economically replace lime in the settlement of slimes, but some means might be found to obviate its deposition from the solution in the precipitation boxes. The subject of the production of suitable anodes for precipitation of gold from cyanide solutions is probably not exhausted, but the field has been very thoroughly explored by able electricians and chemists, and, beyond the

two anodes mentioned, the author does not know any that will fulfill the required conditions.

The anode has attracted a good deal of study, but the subject of the cathode is not less interesting and important. Many substances have been tried, which have performed their functions more or less completely. Lead has been used in thick plates, in thin sheets, in ribbons and strips, and in the form of shavings while zinc has been used in the form of amalgamated plates, and as shavings; amalgamated copper plates have similarly been tried, together with iron plates and various other forms of iron; and the same with mercury. Zinc, copper, and iron in various forms have been utilized by Mr. Andreoli for this purpose; mercury has been used in the United States in the Pelatan-Clerici Process. Each of these various cathodes has its peculiar advantages. Lead strips are used everywhere in the plants using the Siemens process, except at the Central Works, where part of the boxes are charged with lead shavings; and at the Comet, zinc shavings are in use.

In the actual running or precipitation of the liquid in the Siemens & Halske box, there are only a few things to which it is necessary to give attention. Having set the current, and knowing the capacity of the precipitating plant for a certain grade of solution, all that is required for the period of one or two months is, at the commencement, to see that the connections have been properly cleaned, and are in order, then to keep a constant flow of clear liquid through the box, then to see that the same current is maintained throughout, after which no further attention is required. The guide as to when the clean-up should be made is the condition of the cathode.

The cleaner the cathode can be kept, the larger will be the amount of gold that can safely be precipitated upon it; and the steadier the current is kept, the more solid and perfect will the plating be. So long as the surface of the lead remains clean and the coating regular, so long the precipitation of the gold will take place; but under ordinary circumstances, such as prevail in our precipitating plants to-day, it is not usually advisable to retain the lead in the boxes for more than two months. Possibly, if the lead can be kept clean, three months might be given to the lower boxes, because they are generally cleaner than the upper boxes; deposition of the lime and other substances that tend to destroy the efficiency of the cathode is most apparent in the head boxes. The author concludes his notes on this subject by some complimentary remarks on the work of A. von Gernet, M. Torrente and G. Andreoli.

### ELECTRODE CONNECTIONS FOR ELECTROLYTIC VATS.

A paper of Mr. A. VON DESSAUER deals with the electrical connections for electrolytic vats, used in the precipitation of gold. He distinguishes between permanent connections and detachable or movable connections. The permanent connections are left untouched for months and months, and are best effected by soldering or rivetting the wires to the main cable; all anodes in the industrial electrometallurgy of gold ought to be connected this way. On the other hand, the cathodes are to be removed at intervals of one or two months, and their connections must therefore be detachable.

A connection of the latter kind is the arrangement known as "mercury trough." It is a groove of a ¼ inch width by 1 inch depth, cut in wood and filled with mercury. The wires from the electrodes are simply dipped into it, which is a rapid way of effecting a contact. But in spite of that, this system is discarded, because the current has to travel a long way to the main through mercury, which has such a high specific resistance that a very considerable loss of voltage has to be sustained to overcome it. Several improvements have been tried to this trough by sinking copper wires to the bottom of the trough, and by connecting these to the main, or by replacing the wooden trough by bent copper tapes closed with soldered ends. None gave satisfactory results; the latter failed because the solder soon became amalgamated, brittle and leaky.

A dry metallic detachable connection, effected by using screws or holding-down bolts, is very good so far, but it is rather expensive, and neither rapid nor reliable. One way of doing it is by running a galvanized screw through the main copper cable in the partition of the precipitation box beneath, and by so pressing the wires of the single electrodes down with the aid of a small copper tape. But very soon these screws do not bite any more in the wood, and the contact becomes problematical. For this reason an alternation has been adopted by which the screws are stationary and pointing upwards, and the nuts (either ordinary or butterfly nuts) are adjustable, traveling downwards. This is a good connection, as there should be no loss of tension of current so long as a proper contact is effected. But it is doubtful whether this is achieved every time. The main, the wires from the electrodes and the copper tapes have to be cleaned after every clean-up with emery paper and files. This is expensive maintenance. It will take many hours to connect on all the cathodes after a clean-up, and it will take many days, according to the size of a plant to do this cleaning of the contacts. By the first operation the restarting of precipitation is retarded, whereas a plant cannot be in perfect running order as long as the latter operation is not completed.

Hardly any of these shortcomings are to be found with the Carlin tube. This tube is simply an ordinary pipe, best of iron, closed at its ends with screw plugs, and filled with mercury. As many holes are drilled into the top as electrodes have to be connected on. These holes might be round, and just a little larger than the connecting wires, or they might be oblong in shape, in case thin copper wires are used, which latter are best bent loop-shaped to sink through the slot, and to slip them well into the pipe.

The size of the pipe is calculated in the ordinary way in proportion to the current it has to conduct. Half-inch pipe will usually be found ample. One or both of the end plugs are split to receive the main, which will be held in its place by a brass screw. Instead of an iron pipe, others of brass or copper might be used, but there is then the danger of amalgamation. The pipe might also be replaced by a solid iron bar, with a long groove or single holes, to save mercury, in which case the holes must be a little larger, forming simply little cups filled with quicksilver.

The tube was then tried at the May Consolidated in place of the wooden mercury troughs. A 4-foot by half-inch iron pipe was laid down for two joining compartments in one box, and received twenty-six connections. The results were so encouraging that another pipe of brass was made, 8 feet long by half an inch diameter, and received the current from four neighboring compartments of two boxes, or the current from fifty-two cathodes in all. The exact data have been for the mercury trough; terminal tension 3.82 volts, decrease in tension 0.71 volt over the 8 feet of trough, or a loss of 18.4 per cent. (This represents an aggregate loss of 6.39 volt for the May plant, or close to 1,300 watts.) The temperature of the mercury rose at one end to 143.6° F. The distribution of intensity for the different cathodes is very irregular, one receiving twice and two-and-a-half times as much as another in the same compartment. It is therefore obvious that the solutions passing through these boxes encounter very different conditions in the different sections that the precipitation must be faulty.

The corresponding data for the Carlin tube are as follows: With the same tension at the terminals, the decrease over the 8 feet of tube amounted only to 0.015 volt, or 0.3 per cent loss. (Representing an aggregate loss of 0.135 volt, or 27 watts for the May plant provided all mercury troughs were replaced by tubes.) This loss is so insignificant that it can be neglected. It is the forty-seventh part of the loss sustained by mercury troughs.

No heating of mercury nor tube took place, the temperature being almost the temperature of the atmosphere; therefore,

the loss of quicksilver through evaporation is very small. The different cathodes of one compartment show almost the same intensity of current as a consequence of the tube acting as a splendid distributor. Better results will therefore be obtained for the precipitation. It will incur no risk to use a weaker current, as no solution will find a section in the box where it encounters insufficient intensity, and will be allowed to carry its gold away unprecipitated. This means a further saving of power and money.

At a later meeting Mr. von Dessauer described the following connection, used at a South African plant, which is a combination of the wooden mercury trough with metal. A broad copper tape stands vertically in a narrow slot, and is brought by half a twist to the main cable, and fastened with rivets or screws. The tape is large enough in size to carry the current. The receivers for the wires from the cathodes are little cups cut in the wood, semi-circular with ½-inch diameter. The efficiency of this connection, though not controlled by measurements is probably as good as that of the Carliss tube.

### Influence of Temperature in the Cyanide Process.

In the presidential inaugural address of Dr. J. Loevy he referred to some laboratory experiments concerning the influence of temperature on the solution of gold by cyanide. In treating pyritic ore containing about four ounces of gold per ton, with a solution of cyanide at 40° C., the extraction obtained after four hours leaching was 14 per cent higher than that obtained by leaching the same ore with a solution of the same strength for fifty hours in the cold. He remarked that it would be for the practical engineer to find out whether a heating of the solutions is possible on a commercial basis.

Mr. G. A. Darling had gone through his note books from 1890 to 1898 to see if there was any appreciable difference in the extraction obtained during winter and summer months. By dividing the years into six hot months, and six cold months, he found that the average extraction for the cold months was 69.5 per cent, and for the hot months 72.2 per cent. By dividing the years into four seasons, each of three months, he found that the average extraction of six years working was for spring 68.3 per cent, summer 70.6 per cent, autumn 69.5 per cent, and winter 68.8 per cent. These results are given irrespective of any changes of the method of working.

Mr. A. von Gernet had made some experiments in which the exhaust steam from a small engine was run through four pipes in one of the vats from which the solution enters the extractor boxes. By assaying the residue he found that the extraction was increased by the heating of the solution. He did not give any exact figures.

Mr. J. R. Williams did not think that the higher extraction in the summer months has anything to do with the temperature; it is simply that there is a lot of water in the dam, and the organic matter becomes neutralized. Mr. F. F. Alexander also stated that during the cold weather they have a large amount of iron salts in the water, which affects the extraction. He thinks the same extraction can be got by cold water, provided it is pure, that one gets by hot water under the same conditions. Dr. Loevy stated, however, that by heating a solution to over 35° degrees C., the extraction is distinctly increased.

### Potentials of Electrodes in Solutions.

Prof. A. von Oettingen, of Leipzig, Germany, presented two papers to the Society, giving, in the first, a general review of the modern theory of solutions, and in the second the application of the electrolytic dissociation theory to the explanation of the action in galvanic cells. From the latter paper the following remarks are taken which are interesting, since some points of the modern theory are here presented in a way which should appeal to practical men interested in the cyanide process.

Sugar molecules in solution exhibit osmotic pressure; solid sugar itself has a tendency to dissolve, which is analogous to the vapor-pressure of ice. When a piece of ice is placed in a vacuum it will evaporate until equilibrium is attained—that is to say, until the amount evaporated during any interval equals the amount condensed during the same time. Similarly, the sugar dissolves until an equilibrium between its dissolving tendency and the osmotic pressure is established.

Nernst first offered the following explanation of the actual tendency of metals to dissolve, or to change from the metallic to the ionic state. In this case the problem is somewhat more complex than with sugar-molecules, since the metallic atoms in changing their state must take up an electric charge; without this change they cannot dissolve except as colloids, as, for instance, colloidal gold in water. A piece of zinc placed in acid is instantly covered with a sheet of positive zinc ions, while the metal itself becomes simultaneously charged with negative electricity. The extent to which this takes place depends on the tendency of the metal to dissolve. The metallic zinc receives a negative charge, and the solution a positive one. In a very short time the distribution of the electricity is complete, but the newly formed zinc ions cannot pass into solution. They repulse the positive ions of the acid and attract the negative ones, but without combining since in a solution the number of cations and anions must be equal. If another metal be then immersed in the same solution, the repulsed ions will immediately cover it in the form of cations, and charge the metal positively until a certain positive potential is attained and an equilibrium established. This is the open galvanic cell.

Many metals—as, for instance, potassium and sodium—have so great a tendency to pass into solution that they assume the ionic state even in the absence of another metal. In this case the potassium takes the charge from the hydrogen cations, while the latter in the form of a gas, passes out of the solution. In the same way at a higher temperature zinc may expel hydrogen, but the process is accelerated by the presence of another metal, or of impurities in the zinc; in these cases the hydrogen becomes visible in the form of bubbles. With pure zinc the development of hydrogen is small.

Another point in which the dissolving of metals differs from that of sugar is the following: In a saturated solution of sugar the osmotic pressure equals the tendency of the solid sugar to dissolve. But the dissolving tendency of zinc is much greater than the osmotic pressure of the zinc ions, even in a saturated solution of zinc salt. The zinc, hence, acquires a negative potential in saturated solutions. Sugar cannot have any electrical potential at all.

The potential of various metals in saturated solutions is very different, since their respective tendencies to dissolve are sometimes greater and sometimes less than the osmotic pressure of their ions. Thus, copper in a saturated solution of cupric sulphate acquires a positive potential, and the fluid a negative one. In an open Daniell cell zinc has a negative potential and the copper a positive potential. As soon as these potentials are acquired, the process of ionizing stops in the open cell because an electrostatic equilibrium is attained. As soon, however, as the copper is connected with the zinc, a current is developed, the positive electricity from the copper ions entering the metallic copper, and from this passing on to the zinc, which is thus discharged. The copper ions having been thus discharged and deposited, a new sheet of cations passes out. At the same time zinc ions pass into solution, and a new sheet of zinc molecules assume the cationic state, leaving the metal itself negatively charged. In this manner a continuous current is set up.

When two metals are in contact no difference of potential exists, or merely a very small one, measurable only in thousandths of a volt; this is due to thermo-electric currents, and may be neglected. It may be noted that the term "couple"—as, for instance, of zinc and lead—was used formerly to express the idea that the electricity in a circuit was produced by the

contact of two metals. This theory of Volta, and of many philosophers until recently, is now known to be erroneous. We now understand that zinc exhibits a potential towards the solution in which it is immersed, as does also the lead. When the circuit is closed the electric current is allowed to pass from the lead to the zinc, and this process continues. In this sense only can the term "couple" be used, because the presence of a second metal is a necessary condition for a continuous electric current, although the electricity produced by contact is quite insignificant, and in no way the source of the current. The real source of the current is the energy derived from the zinc in its transformation into positive zinc ions. At the contact of the sulphuric acid and cupric sulphate in a Daniell cell there is likewise a small difference of potential but this is so small that it may be neglected, and the e. m. f. of the Daniell cell becomes, according to Nernst's theory, equal to

$$RT\left(\log\frac{P_z}{O_z} - \log\frac{P_c}{O_c}\right),$$

where R is the gas-constant, T the absolute temperature (= degrees C. + 273), $P_z$ and $P_c$ the tendency of zinc and copper respectively to dissolve (Nernst's "solution tension"), and $O_z$ and $O_c$ the osmotic pressures of the cations of zinc sulphate and copper sulphate, respectively. The quantities $P_z$ and $P_c$ are constant, while the osmotic pressures vary with the concentration. The electromotive force being greater in sulphuric acid than in zinc sulphate, the potential will decrease as more zinc ions enter the acid. On the copper side the reverse is the case, because the more cupric sulphate is in solution the greater is the potential, the osmotic pressure being greater than the tendency to dissolve. Since $P_z$ is greater than $O_z$ while $P_c$ is less than $O_c$, the two terms of the equation constitute a sum, and not a difference. It is remarkable that potentials are independent of the chemical nature of the anions; the potential, for instance, of

Zn, $ZnSO_4$, $CuSO_4$, Cu, and
Zn, $Zn(NO_3)_2$, $Cu(NO_3)_2$, Cu,

being the same. The anion influences the degree of dissociation of the compound, and, hence, the acid radicle affects the potential indirectly by its influence on the osmotic pressure.

Such cells as Daniell's are reversible, if electrical energy be expended to drive the copper into, and the zinc out of, solution. The electrical energy required is P × 96,540 volt-coulombs (or wattsec.) for one gramme-equivalent of deposition of zinc and solution of copper. If an electrical source of energy be employed, of which the potential $P_1$ is less than P, there will be no current. If $P_1$ is greater than P, there will be both a current and a deposition of metal proportional to $P_1 - P$, and not to $P_1$ simply. In some cases of great interest the potential of a metal appears greater than usual. For instance, the potential of zinc in contact with sodic or potassic hydrate is greater than with sulphuric acid. The reason of this is that in the first case no zinc cations are formed, the zinc atoms passing into the anions with formation of an alkaline zincate. If there were no osmotic pressure due to zinc cations, the formula already cited would give an infinitely high potential, because $O_z$ in $\log\frac{P_z}{O_z}$ would be nil. As a matter of fact, however, it is considered that a small portion of the anions $ZnO_2$ (with two negative- charges) are dissociated into Zn (with two positive charges and $O_2$ (with four negative charges). Such zinc cations may be termed cations of the second kind, or meta-cations. In the foregoing instance Zn (with two positive charges) would be a meta-cation, and $O_2$ (with four negative charges) would be a meta-anion. Exact formulæ for the potentials in such cases are not known, since the whole problem of the dissociation of complex ions has yet to be fully investigated. We know, however, that such decomposition occurs, since we obtain meta-cations on the cathode, and it likewise follows from Guldberg and Waage's law of chemical mass action.

Sometimes the sign of the potential changes. Copper, for instance in cupric salts is always positive. But it receives a negative charge when dipped into a solution of potassic cyanide; the molecules of copper here tend to be dissolved and become part of the univalent anion $Cu(CN)_2$. Copper dissolving in this manner may even expel the zinc from a zinc sulphate solution, the expression $\log\frac{P_c}{O_c}$ for copper being greater than $\log\frac{P_z}{O_z}$ for zinc. In such a combination it may be that the copper dissolves, and zinc is deposited in crystals on the zinc electrode without any current from an external source.

The same thing takes place with gold. Metallic gold immersed in most solutions has a positive potential, gold cations having usually a great tendency to assume a metallic state, while metallic gold dissolves with difficulty. This behavior is indicated by the popular term "noble," which is applied to such metals. In cyanide solutions, however, gold does not act the part of a noble metal, since it dissolves, as part of the anion. This exception to its general behavior is of the greatest practical importance, since, were it otherwise, the cyanide process would not exist.

The difficulty of recovering the gold from cyanide solutions is obvious, from this point of view. The electric current causes the univalent cation K to migrate to the cathode, while the anions $Au(CN)_2$ travel to the anode, as pointed out by Hittorf. How, then, is the gold deposited on the cathode? This can only be explained by assuming that the osmotic pressure of the univalent meta-cations of Au is sufficient to cause their deposition thereon. Since the anions containing the gold are migrating to the anode, it is obvious that the movement of the whole solution is a most important point, and greatly assists precipitation by counteracting the migration of the gold anion.

By electrolysis of a solution of $Na_2PbO_3$ the cations $Na_2$ and the anions $PbO_3$ carry the current; however, metallic lead is deposited on the cathode as a meta-cation Pb (with four positive charges), while the meta-anion $O_2$ (with six negative charges) is set free on the anode, together with the anion $PbO_3$ (with two negative charges).

To deposit any given metal on the cathode the potential of the electrical source of energy must be sufficiently high to overcome the potential of the metal in solution. Thus, in a mixture of salt solutions in water—as, for instance, of the nitrates of Ag, Cu, Cd, K, and Zn—if small currents are first employed, and the voltage subsequently gradually increased there is first deposited pure silver, then copper, then hydrogen, cadmium, and zinc, in the order given. All the cations in these solutions are traveling towards the cathode with a velocity depending in each case upon the concentration of the solution and a special constant. The deposition of a metal upon the cathode depends upon its osmotic pressure in comparison with its tendency to dissolve.

By using Ostwald's mercury "normal electrode," the potential of which is taken as—0.560 volt, the author determined the potentials of gold when dipped into various solutions at 25° C. The figures obtained were as follows:

| | | | |
|---|---|---|---|
| Au, AuCl (conc.) | = — 1.64 to — 1.42 | volts | (variable) |
| Au, N.$AuCl_3$ | = — 1.134 | " | |
| Au, Aqua Regia | = — 1.09 | " | |
| Au, KCNS (sat.) | = — .26 to + .03 | " | (very variable) |
| Au, KCN (sat.) | = + .50 | " | |
| Au, $K_2S$ | = + .14 | " | |
| Au, $K_2S_7$ | = + .21 | " | |
| Au, $Na_2S$ | = 0 to .136 | " | |

From the above it is observed that in cyanide solutions gold readily passes into solution, since there is no primary osmotic pressure to hinder the dissolving process.

Some potentials of various electrodes in saturated cyanide solution are added:

| | | | |
|---|---|---|---|
| Saturated KCN with Au | = + 0.50 | volts. | |
| " " " Ag | = + 0.536 | " | |
| " " " Cu | = + 1.154 | " | |
| " " " Zn | = + 1.196 | " | |

Furthermore, we have the potential of a Zn electrode in $ZnSO_4 = +0.524$. Hence, it is obvious that in the combination Zn, KCN(sat.), $ZnSO_4$, Zn
we can expel the zinc on the right by the zinc on the left. And even in the combination

Cu, KCN(sat.), $ZnSO_4$, Zn

the zinc may be deposited by the dissolving of the copper, since, though the potentials are opposed, there is a plus difference; thus,

1.154 volts $-(+ .52$ volts$) = + .63$ volts.

### Zinc Versus Electrolytic Precipitation.

In his inaugural presidential address Dr. J. Loevy remarked that in spite of the undoubted advantages of the Siemens & Halske process, the war cry will, for some time to come, continue to be "zinc versus electric precipitation." The speaker said that apart from the generally asknowledged fact that the Siemens & Halske process was, up to that time, the only precipitation process coming into consideration for the slimes treatment, it is to be credited with being the cause of important improvements in the zinc process, thus showing that competition is always beneficial to an industry. Furthermore, the Siemens & Halske process has been the impetus for a considerable amount of research work.

Mr. T. L. Carter took exception to the statement that the Siemens & Halske process is the only suitable one for slimes treatment. He has found the following process to be quite effective at the Crown Deep, which had originally six Siemens-Halske boxes (40 by 6 by 5 feet, divided into 9 compartments). At the time when he read his paper (October, 1898), only half of one box was used, that being sufficient for the zinc method of precipitation. A very important point is the preparation of the zinc. After it has been cut on the lathe it is taken to a trough which contains a solution of acetate of lead of about 10 per cent strength. The zinc is thoroughly washed and stirred in the solution, until it becomes of a dark hue. If it is not thoroughly stirred only the outside of the mass of zinc will become coated, the inside remaining quite bright. An empirical way to ascertain whether or not the solution is strong enough, is to look at the zinc and to see if it is sufficiently and thoroughly coated. After thus preparing the zinc, it is placed in the box and covered with the auriferous solution as quickly as possible, since leaving it in the air seems to adversely effect it.

The next important point is the addition of free cyanide at the head of the box. Twenty pounds of KCN are dissolved in an iron tank holding about 75 gallons of water. This 2½ per cent solution is allowed to run freely into the auriferous solution, entering the box for a period of about four hours, raising the strength of the solution passing through from 0.007 per cent to 0.025 per cent. When the 20 pounds of KCN are finished another 10 pounds are dissolved as before, and freely run into the box, taking a period of six hours, and raising the solution about 0.007 per cent higher. By no means should the addition of the cyanide, as described, be neglected, for it is found absolutely necessary at the commencement to let this free cyanide run into the box. Twelve or fourteen hours after starting, a slow drip is allowed to fall into the solution as it enters the box, bringing up the strength of the solution going through the box from 0.007 per cent to 0.008 per cent, and this is continued through the run of the box. The first four or five days the precipitation seems to be very quick, and almost perfect, but later the zinc becomes gradually "dead." The process was worked with success at the Crown Deep by Mr. W. K. Betty. While the use of lead in conjunction with zinc was patented by Mr. MacArthur at an earlier date. Mr. Betty claims originality for the conjunction of free cyanide, lead, and zinc, by which he gets an almost perfect precipitation from solutions so weak in cyanide that it was formerly considered hopeless to attempt to make them amenable to precipitation on zinc in an ordinary zinc box.

In the discussion which extended over several meetings Mr. A. von Gernet stated that he had tried the process for several months, and the difficulty which occurred was in the formation of a ferrocyanide of zinc, which, in the form of a white salt, covers the zinc and checks the precipitation. The more the solution gets saturated with iron salts, and the more that reaction takes place, the quicker the point will be reached where precipitation ceases. The time taken to reach this point depends in a great measure on the ore, as some ores contain much soluble iron, in which case the solution soon becomes saturated and the formation of ferrocyanide of zinc takes place quickly. In the treatment of acid slimes, which always contain a large proportion of soluble iron, the formation of ferrocyanide of zinc takes place almost immediately, and to such a great extent that unless there is added continuously a large amount of cyanide to the boxes there will be precipitation only for a few days. There seemed to be a general disposition on the side of many members to question the novelty of the process.

Mr. J. R. Williams expressed the opinion that the Siemens & Halske electrolytic process is specially suitable for impure ores. By impure ores he means where other metals than gold are freely soluble in cyanide, such as carbonate of copper, etc.; such an ore he has at Pilgrim's Rest, where the zinc in a very short time after being placed in the precipitation boxes looked like so many ribbons of copper. Mr. J. MacIntyre agreed with him that where large quantities of copper are present, the electrical method is the effective one. Mr. Williams stated that there is a great uncertainty of the Siemens & Halske process, since one day one gets good precipitation, and the next day one does not; he also claims that there are considerable losses of gold in the Siemens & Halske process. Mr. A. von Gernet remarked that wherever there was found an uncertainty in the working of the Siemens & Halske process it was always found to be due either to the fact that the box capacity was too much up to the limit, or else to stoppages in the power plant.

Mr. Carter gave the following comparative figures on the cost of the Siemens & Halske process, and the zinc-lead process on the same plant, although after the introduction of the zinc-lead process the tank capacity had been somewhat increased. For April, May and June, when the Siemens & Halske process was used, the total cost, comprising cyanide, lead foil, power and royalty was 27 cents per ton of slimes treated. During July August and September, on which an experimental run was made with the zinc-lead process, the total cost, comprising cyanide, zinc, sulphuric acid, power, lead acetate, was 21 cents per ton. During October and November, when the zinc-lead process was worked under normal conditions total cost was somewhat more than 12 cents per ton. He also stated that he had transferred the zinc after being used in a slimes plant over to their sand-boxes, and had been very successful in this respect. Mr. R. E. Hall gave some data in connection with the Siemens & Halske precipitation in the Ferreira slime works. After the first six months of 1898 he had a theoretical extraction of 80.18 per cent, and an actual extraction of 76.09 per cent; afterwards the theoretical extraction was slightly higher. In using the zinc process, although without free cyanide, he experienced much trouble. Mr. Durant claimed that in the great majority of cases the Siemens process has been successfully worked under the care of different men, many of whom had no technical training whatever, and the results they obtained left little or nothing to be desired. He ridiculed the claim of some mysterious disappearance of gold in the Siemens precipitation boxes.

Mr. H. T. Durant remarked that the addition of free cyanide is to prevent the formation of insoluble zinc compounds, which would stop precipitation. Mr. W. Bettel remarked that since the action of the free cyanide has long been known to be to dissolve the zinc compounds coating the zinc, he cannot find anything new in Betty's process. Since he is himself the inventor of an electrolytic rival process, he said he could not be

regarded as a supporter of the Siemens & Halske method, but due credit should be given to the latter. "The alleged 'eccentricity' of electrolytic precipitation said to exist is merely a stalking horse or bogey, put up by persons whose knowledge of electrometallurgy is slight, and whose opinions must therefore be accepted with reserve. Mystery is always a hobby-horse of the so-called 'practical' man." He had observed with regret, tinctured with amusement, that when the extraction of gold from slimes happened to be low in nearly every case the unreliability of electrical precipitation was cited as the cause, and there the matter ended, no effort, or very little, except in rare cases, being made to get at the truth, which might very often have been traced to causes very far removed from its assumed origin. He expressed his belief that the day is not far distant when the demand for "kindergarten processes" (suitable to persons of limited understanding) will cease, and men will have to fit themselves for working modern metallurgical processes which require a certain amount of skill and attention, and which, when properly worked, will yield more profit than methods which seem the acme of simplicity—and slovenliness.

Mr. M. B. Zerener criticised the comparative figures of Carter for the cost of two processes, especially on the ground that according to his figures a considerably greater cost of cyanide is charged for the electrolytic process than for the zinc lead process. Mr. J. R. Williams gave comparative figures for his working of the Siemens & Halske process during 1898, and for two months, working with the lead-zinc couple. In the following, the first number always refers to the Siemens & Halske process, and the second figure to the lead-zinc process: Theoretical extraction, 71.4 and 72.6 per cent; actual extraction, 54.9 and 70.15 per cent; working cost per ton, 85 and 82 cents; profit per ton, 97 and 141 cents. He therefore concludes that by the introduction of the lead-zinc process the actual extraction has been increased by 15.25 per cent, the working cost has been reduced by nearly 4 per cent, while the profit has been increased by 44.8 per cent.

Mr. Durant denied that this comparison is decisive. If in a slimes plant, where the Siemens process is installed, and 88 per cent actual extraction can be maintained over an average period of six month, on, say, 4 dwts. slimes (which is the case), then, when other plants can only obtain a 50 or 60 per cent extraction, it is not the process that is at fault. They have made a comparative test at the Robinson slimes plant, the plant being divided, and with the solutions separate, one part being run with the Siemens process, and the other with the lead-zinc couple. The results obtained from the lead-zinc side were most unsatisfactory, the process being very variable, very expensive as regards cyanide, and most wasteful in the method of clean-up. However, there were many reasons why bad results were had in this plant by the use of a lead-zinc couple. The principal one he believes to be due to the aeration of solutions, since it has been found by tests that the introduction of air into a zinc box redissolves the gold from zinc. It is therefore evident that well-aerated solutions will not yield the same results as unaerated solutions. He emphasizes that in the solution from slimes aeration is the most important feature. Consequently, even if using the lead-zinc couple, one could not recommend giving up aeration (although detrimental to precipitation), for the reason that in the treatment of slimes aeration in the presence of cyanide is the best-known method of dissolving gold. On the other hand, in the electric process, the benefit of aeration can be had in treatment without any detrimental effect in precipitation, as air in the solution does no harm. He then gave some information on an experiment made on a large scale comparing the relative merits and demerits of the zinc process, as against the Siemens electric process, both sides being well represented. For a few months the results obtained were for various reasons not such as would be indicative of the normal working of the electric process, for the reason mainly that one solution pump and one pipe line was used for both the zinc and the electric solutions. This introduced zinc into the electric precipitation boxes, while it is now well known that zinc is fatal to successful electric precipitation of gold by the Siemens process. The experiment was then stopped and was taken up again after a month. Mr. Durant gives the figures for the two following months, July and August, which show some superiority of the electric process.

Mr. W. H. Wood gave comparative figures for the first cost of installing an electrolytic Siemens & Halske and a zinc-lead plant for slimes treatment, for a one-hundred-stamp proposition crushing 500 tons per day, the only difference between the two plants being assumed to be in the extraction house. He gives as first cost for the zinc-lead process $2,190, against $10,712 for the Siemens & Halske process. These figures, of course, refer only to the first cost of the extractor houses, not to the cost of working.

Concerning the whole comparative test made with both processes (mentioned above by Durant), it appears that the electric process was in general somewhat less economical than the zinc process, but, as Durant stated, there were so many objectionable points that he refuses to accept the test as representing the normal running of the electrical process. He believes that the two months, mentioned above, in which the electrical process showed a slight superiority, were the only ones in which the conditions were equally fair to either side. The full figures for the working of the two processes during the whole run of the test may, however, be found in the proceedings; as mentioned before, they are, taken as whole, in favor of the zinc process.

In a paper on precipitation of gold from cyanide solutions, Mr. A. H. Hartley gave some facts which seemed to show that copper-bearing ores would seem to present no difficulties to the successful treatment of tailings and slimes by the usual zinc method of precipitation. Mr. J. R. Williams, however, remarked that his experience was that, while small quantities of copper do not effect precipitation at all, yet, when it comes to an excessive amount, the Siemens & Halske, or any other good method of precipitation will hold its own. He thinks the more impure ore is in that way, the more necessity there is for electrical precipitation.

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## THE RARE ELEMENTS.

By Victor Lenher, Ph. D.

(Concluded from page 13.)

The class of substances which are designated as the *rare earths* comprise a large number of bodies, some of which are fairly well defined as chemical elements, while with a large number grave doubts can be cast as to their simplicity. Indeed, to many chemists the term "rare earths" is a phrase which means a group of elements whose chemistry is in more or less of a confused state and tangle. The great problem presented by these substances is their similarity, and their similarities are so great, in many cases, that it is an arduous and painstaking labor to separate even the sharpest defined ones of them into even reasonably pure substances. Yet it is to this group of bodies that we owe our present highly perfected incandescent gas mantles, the manufacture and construction of which affords employment for thousands of men, and represents an investment of millions of dollars of capital.

The chemical reactions of the rare earth group are such as to call forth attention to their general resemblance to the more common earth alumina and to the alkaline earths magnesia and lime.

Among the rare earth metals are listed thorium, zirconium, yttrium, erbium, terbium, scandium, samarium, cerium, lanthanum, neodymium, and praseodymium. The existence of the above-mentioned has been established to most chemists in a

fairly satisfactory manner; at the same time, mention should be made of a number of earths for which much may be said for and against, so far as simplicity is concerned. Among these are holmium, decipium, phillipium, thulium, dysprosium, metacerium, and a number of unnamed earths.

With the above array of earths, each presenting his own individual claims for recognition, some of which may be well said to be substantial, while others are not, it is little to be wondered that the average well-informed chemist does not view the undertaking of an analysis of such a mineral as monazite or samarskite with feelings of pleasure. Again, the rarity of most of the earths, and the fact that so few find any practical uses are frequently obstacles to investigation. All the time when dealing with the rare earths, one must remember that frequently only a single reaction can be used to differentiate from other earths and not infrequently this reaction is a slight difference in solubility of a given compound. For example, in 1885 Auer announced that by the fractional crystallization of the double ammonium nitrates from a strong nitric acid solution, and repeating the operation hundreds of times, it was possible to separate the old didymium of Mosander into two earths, to which he gave the names Neodymia and Praseodymia. Again, yttria and erbia are separated by repeatedly heating the nitrates and fractional crystallization from dilute nitric acid.

It is particularly worthy of note when considering the simplicity of the earths to observe that Moissan in his work on the carbides of the rare earth metals always found that when treated with water the carbides gave a complex mixture of hydrocarbons containing not only methane, ethylene, acetylene, and even hydrogen, but liquid and solid hydrocarbons, while carbides of such elements as throughout give clear-cut compounds as aluminium and calcium, a single simple hydrocarbon is the only product formed.

The usual division made in the rare earths is the reaction with potassium sulphate in saturated solution, cerium lanthanum and the didymiums form double insoluble potassium sulphate, and are thus separated from the erbium group whose double sulphates are soluble.

The most important commercial point in the rare earths is the incandescent gas mantle. As early as 1826 Lieut. Thomas Drummond found that lime and magnesia when heated in the oxy-hydrogen flame became incandescent, and that zirconia was more refractory and gave an intensely bright white light. This gave rise to the idea of using a highly heated oxide as a source of light. While these lights have seen great service, the great objections have been the production of such a high temperature as the oxy-hydrogen flame and the difficulty of obtaining a lower candle power without a tremendous loss of efficiency. It was only about 1886 that Auer von Welsbach demonstrated that with the heat of a small Bunsen flame it was possible to produce a light of high candle power by directing the flame on a mantle composed of the oxides of thorium and cerium. The composition of the mantles on the market and in common use to-day is the normal Welsbach mixture of 99 per cent of thoria to 1 per cent of ceria. The best mantles when new give with the ordinary burner about 100 candle power. This high candle power rapidly drops at first and then falls slowly, the greatest cause being the volatilization of the ceria at the intense heat, whereby the composition of the mantle is materially changed.

*Vanadium* and *uranium* have received more attention in the past few years in this country from the commercial side than heretofore, largely due to the discovery of the uranium and vanadium deposits in Western Colorado. Very little of the ore is, however, worked up in this country; the most that is taken out is shipped to Paris. In the Colorado deposits uranium and vanadium are found together in what appears to be complex minerals. Uranium also appears in Colorado and in several places in the West as pitchblende.

The use of vanadium has been repeatedly suggested in the manufacture of high-class steels, tool steels, and armor-plate steels, but very little has been done outside of the experimental stages. Results have been obtained, however, which look promising—vanadium hardens steel and in addition the steel can be used at a high temperature. The chief uses which vanadium compounds have, are in calico printing, in the manufacture of aniline black and in the coloring of glass. The usual compound employed is vanadic acid.

Uranium has been repeatedly suggested for use in the manufacture of high-class steels, but very little uranium steel is to be found on the market at present. Considerable quantities of uranium are used in the manufacture of uranium glass, which gives a peculiar yellow green fluorescent appearance, and in porcelain painting to give a fine velvety black color.

*Columbium* and *Tantalum*, from their contradictory chemical characteristics, are frequently called the "metallic acids." Their principal source in nature is in the minerals columbite and tantalite, although quite a number of other rare minerals contain larger or smaller quantities of the elements as oxides. The usual method for extracting the oxides from columbite or tantalite consists in fusing the finely powdered mineral with potassium bisulphate. The fused mass is treated with water, then dilute hydrochloric acid, and digested with ammonium sulphide, which removes iron, tin, tungsten, etc. After washing with water, the purified oxides are dissolved in hydrochloric acid, potassium fluoride is added and the solution crystallized. Potassium tantalum fluoride separates out first in needle-like crystals, while the more soluble oxyfluoride of columbium appears in plates on further concentration. Both of the metals have been prepared in elementary condition, by reduction with sugar carbon, in the electric furnace by Moissan.

Neither of the metals or any of their compounds thus far have had commercial application.

*Selenium* is a particularly interesting element on account of its action towards light. The element is obtained in three allotropic forms, *viz.*, red amorphous, black crystalline, and black glassy. The red amorphous variety which is the form usually obtained by the separation of the element from one of its compounds at the ordinary temperature, is a non-conductor of the current. Under the influence of heat it is transformed into the crystalline variety whose conductivity increases enormously in the light as compared to that in the darkness. Both of these varieties are converted into the black glassy modification by heating to 217° C., the melting point of the element. When, however, the black variety is held for some hours a few degrees below its melting point, it is completely converted into the black crystalline form. This is the method commonly employed for the preparation of the so-called selenium cells. The usual form of cell consists of two copper wires wound spirally around a mica, glass, or porcelain plate. The space between the wires is filled with selenium; the whole apparatus is then heated for four or five hours to a few degrees below the melting point of selenium, when the black crystalline variety is produced. The selenium cell, thus prepared, enormously changes its resistance to a current when brought from the dark into the light. Many uses have been suggested for this interesting piece of apparatus, such as sending pictures over a wire, automatically lighting gas street lamps, etc. Unfortunately, selenium cells thus far have not been found to be permanent and reliable, and the reason for their deterioration has not been satisfactorily accounted for. The formation of copper selenide is probably one of the factors, but the whole subject is certainly one which merits further research. Selenium is found in nature in certain iron pyrites, and in some localities in natural sulphur; it is similar in its chemical characteristics and compounds to sulphur, though not nearly so pronounced a non-metal. One of the principal sources of selenium is in the flue dust deposits from the manufacture of sulphuric acid by the lead chamber process.

*Tellurium* in many respects much resembles selenium. In its

conductivity and in its action towards light there is, however, no resemblance. While its resistance is high, there is no fluctuation in the light as compared to the darkness.

Tellurium in nature usually accompanies gold; in fact, we have not only the rich telluride ores, but native tellurium itself usually carries larger or smaller amounts of gold.

The sulphide copper ores frequently carry small amounts of tellurium, and in electrolytic refining of copper, the slimes formed often carry considerable quantities of tellurium.

The telluride ores are the most refractory class of all of the gold ores, so far as economical treatment is concerned, and the methods for extracting the gold are proportionately expensive.

Thus far tellurium and its compounds have had no commercial value; in fact, in most cases, tellurium seems to be an element which in the commercial way should be rather avoided than cultivated. Small quantities of the element tend to destroy some of the most valuable properties of many of the metals and their alloys. The compounds of tellurium are poisonous, and in many cases the element as a contaminating substance is difficult to eliminate.

From the pure chemical standpoint, tellurium is original in being the glaring exception to the periodic law, its atomic weight, 127.5, is higher than that of iodine, 127, while theoretically it should be several points lower. A large amount of attention has been given to this point, particularly in the past few years, but thus far it has withstood all attempts to break the element down to more simple forms, and for the present we must accept the atomic weight which has successfully stood the tests of years of careful and elaborate experimentation.

*Molybdenum* and *Tungsten* are two elements which in many respects possess similar chemical characteristics. They occur associated together in nature, the one usually appearing as a contaminating material with the other. The chief source of molybdenum is the sulphide, molybdenite from which it is extracted by roasting, and the resulting trioxide is purified by sublimation. Molybdenum trioxide, commonly known as molybdic acid and the ammonium salt, find considerable application as reagents for the determination of phosphorus. The alkaline molybdates, especially sodium molybdate, are used in the production of bright blue colors on crockery, and molybdic acid or one of its salts is used to more or less extent in the dyeing of silk and wool. The production of metallic molybdenum by high temperature methods, need only be mentioned here, and as well the use of molybdenum in the manufacture of high-class steels.

*Tungsten* occurs in nature as wolframite, the tungstate of iron, hübnerite, the tungstate of iron and manganese, and scheelite, the tungstate of calcium. For the extraction of tungsten from these minerals, either fusion with sodium carbonate is resorted to when soluble sodium tungstate is formed, or treatment of the ore with nitric acid when the trioxide is obtained.

Tungsten compounds have considerable use, sodium tungstate is one of the best substances known for impregnation of fibres of various kinds for the purpose of making them fireproof. It is also employed as a mordant in dyeing. The partially reduced tungstates are the very important and beautiful tungsten bronzes which are so largely used as bronze powders and pigments.

It has been known for many years that tungsten, when introduced into steel, renders the latter extremely hard and tough, and it is largely to tungsten that we owe the valuable properties of our highly perfected self-hardening steels.

The *platinum metals* are commonly distinguished as two groups, the first embracing the light platinum metals, palladium, rhodium, and ruthenium while the second contains the heavy platinum metals, platinum, iridium, and osmium.

Of the first group, palladium is the only one which may be said to have a commercial importance, no important applications being made of rhodium or ruthenium. Palladium has the lowest melting point of any of the platinum metals, 1500° C.; it is more malleable than platinum, is steelwhite in color, and does not tarnish. On account of its resistance to oxidation and to the action of hydrogen sulphide, it is used in the construction of the mechanical parts of fine watches, fine balance beams, scales on delicate apparatus, etc.

Perhaps the most striking reaction of palladium is its property of absorbing hydrogen at the ordinary temperatures. It will, at and below 100° C., absorb sufficient hydrogen to form the hydride $Pd_2H$, while palladium black at 100° C. will take up nearly a thousand times its volume of hydrogen.

The heavy platinum metals are all important commercially, platinum so much so that little need be said here except to note that the commercial metal contains small quantities of the other platinum metals, and that this is considered to be beneficial.

Osmium is the most infusible of the group, and is extremely refractory toward reagents. The usual method of attack is to heat the metal mixed with common salt in a current of chlorine gas, when the double sodium chloride is found which is soluble.

Osmic acid is a readily volatile substance, is a very active substance, has a powerful odor, is extremely irritating and poisonous. The acid is used as a black stain for the cross hairs in optical instruments, and in biological work. The element in metallic form is employed in the preparation of filaments for incandescent lights.

Iridium is one of the most refractory metals, and could be used to replace platinum to a considerable extent in the manufacture of crucibles were it not for the fact that it absorbs carbon from the flame, and becomes converted to the carbide. While this carbide is not a stable compound its formation causes the crucible to have a comparatively short life. On account of the hardness, infusibility, and indifference to reagents of the metal, and as well, of the native alloy iridosmium, both find considerable use in the construction of fine bearings, knife edges for balances and in points for gold pens.

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## RECENT IMPROVEMENTS IN DRY CELLS OF THE LECLANCHE TYPE.

BY ADOLF J. MARSCHALL.

The exciting liquid, used by Leclanché in his well-known cell, is a concentrated solution of $NH_4Cl$. Leclanché tried to replace the $NH_4Cl$ by the chlorides of potassium and sodium, but the result was not satisfactory, because no combustion of hydrogen takes place, or, if it does, it is excessively small. The writer has found the same to be the case if a solution of $ZnCl_2$ is used.

The principal action in the Leclanché cell is as follows:

$$2NH_4Cl + 2MnO_2 + Zn = ZnCl_2 + 2NH_3 + H_2O + Mn_2O_3$$

Through secondary reactions several other products are formed, but they are not fully known.

Nearly all so-called dry cells consist of the elements used in the regular Leclanché battery, but no separate container is used, as the zinc pole is in the shape of a deep cup, that forms a container for the other materials. This zinc cup is lined on the inside with porous paper or plaster of Paris and the space inside this lining is then packed solid with a mixture of finely divided $MnO_2$ and granulated carbon, with the carbon pole in the center. The whole mass inside the zinc is dampened with a concentrated solution of $NH_4Cl$ and sealed with pitch.

The more successful cells on the market do not contain $NH_4Cl$ alone, but from 5 to 10 per cent $ZnCl_2$. If this $ZnCl_2$ is not added, the $ZnCl_2$ formed by the action of the cell, will sink down close to the zinc and local action will be set up between Zn in $NH_4Cl$ and Zn in $NH_4Cl + ZnCl_2$. By the addition of the $ZnCl_2$, the local action is very much reduced.

When the cell has been used for some time, the free $NH_3$ will be strong enough to act on the zinc, and if sufficient has been

formed, the zinc cup will be perforated and the cell made worthless.

This presence of free $NH_3$ in the cell changes the chemical actions entirely, but what products are formed are not known.

We have just mentioned that the $MnO_2$ in the cell cannot be reduced by $ZnCl_2$, but the writer has found that by further addition of a *small* amount of $NH_4Cl$, which acts as a catalytic substance, the cell is able to produce as much current as if the liquid had been a concentrated solution of $NH_4Cl$. About 3 per cent $NH_4Cl$, with the $ZnCl_2$, will produce this action, and even if the current is run down to zero, the odor of free $NH_3$ is hardly perceptible when the cell is opened. The composition of this liquid, containing a large excess of $ZnCl_2$ is protected by letters patent.

In this way the local action and the action of the free $NH_3$ is reduced to a minimum and the result is a cell of great keeping quality and energy.

## ELECTROLYTIC ZINC.

By Oskar Nagel, Ph. D.

In comparing the great amount of work of the last years in zinc electrolysis, with the results, we must be surprised to see the disagreeable proportion of the former to the latter. Involuntarily we think that this work was carried on without the proper system and foundation. I will try to show general lines along which a better result might be obtained.

The chemist, in working out a process, is starting work on a small scale, goes over slowly and continuously to a larger scale, and is ending the experiments at last on a manufacturing scale; during this work he is watching continuously the different stages of the reaction, and is changing the circumstances for getting the yield desired. Thereby he is *quantitatively* approaching his intention.

In trying certain reactions with a less known element, the work is advantageously started with a well-known element and carried on by going over to less known substances of the series of tension, connecting the known element with the substance to be worked upon. This is a *qualitative* approach to the solution of the problem.

In trying, for instance, certain zinc reactions, which in similar form can be successfully made with nickel, we will start with the latter, going over afterwards to cobalt, and after studying the reaction on cobalt, take up iron, thallium, cadmium and zinc.

The sequence of the metals from zinc to copper, according to their tension, is:

| | Volt. |
|---|---|
| Zinc | 0.51 |
| Cadmium | 0.16 |
| Thallium | 0.11 |
| Iron | 0.09 |
| Cobalt | —0.02 |
| Nickel | —0.02 |
| Tin | — |
| Lead | —0.10 |
| Hydrogen | —0.25 |
| Antimony | — |
| Bismuth | — |
| Arsen | — |
| Copper | —0.59 |

The present stage of technical electrolysis can shortly be defined as follows. Copper is successfully made in solid plates. The details of this process are well known. There is so far no practical success in making electrolytic arsen and bismuth. Electrolysis of antimony has only resulted in powder. No solid plates are made out of lead (electrolytically). Tin is always obtained in loose powdered form. In trying to precipitate nickel out of salt solutions, no thick plates can be obtained, the precipitate being so brittle that it falls apart. No definite results are published on electrolytic cobalt, iron and thallium. We know only of small laboratory experiments with cadmium. However, it is well known that the electrodeposition in going from copper to zinc gets more and more difficult.

We see now that—especially of the metals *above* hydrogen—no successful technical electrolysis was made so far. For getting a satisfactory result in zinc-deposition, it will be necessary to work out at first all the details of lead electrolysis, going over them and changing, as it seems necessary, the conditions of the experiment to tin, nickel, iron, cadmium and at last to zinc. It is a long way from the electrolysis of lead to zinc, as is shown by considering that for precipitating lead out of normal salt solutions by means of hydrogen, the latter would have to have a pressure of $3.1 \times 10^4$ atm. In the case of zinc the required pressure would be $3.2 \times 10^{22}$ atm.

It is probably incorrect to say that zinc electrolysis would have been farther advanced, by using the systematic way from copper to zinc, according to the increasing tension. But there can be no doubt that thereby much troublesome work would have been avoided, which started with incorrect and weak propositions and foundations. As Gauss, the mathematician, says, "If we experiment, we experiment with our thoughts."

## FIRST MEETING OF THE NEW YORK SECTION OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

In spite of very unfavorable weather, more than sixty members and guests assembled on the evening of January 26th in the Chemists' Club, New York City. They were welcomed by Prof. C. A. Doremus, who, in some well-chosen introductory words, dealt with the success of the Society, and with the role which electrochemistry plays in New York State and city. He explained that New York City was certainly entitled to have its local section.

The success of the first meeting of the section certainly justified the hopes entertained by those interested in the formation of this section. Not only the comparatively large number of members who came to attend the meeting in spite of pouring rain and melting snow, but also the lively and interesting discussions which followed the reading of each paper proved that the New York Local Section has a useful mission to fulfill.

### The Commercal Electrolysis of Water.

A paper on this subject was presented by Prof. J. W. Richards, of Bethlehem, Pa., who first gave an historical review of the commercial systems of the electrolysis of water for producing hydrogen and oxygen. As electrolyte, caustic soda or sulphuric acid are used, with iron electrodes in the former case, and lead electrodes in the latter case, but the use of caustic soda with iron electrodes appears to be now considered to be preferable for commercial purposes.

The main problem to be solved in designing a cell for the electrolysis of water is, of course, to provide means by which the products of the electrolysis—oxygen and hydrogen—are kept separate from each other. Diaphragms are used for this purpose, and according to the nature of these diaphragms all the different commercial cells are sub-divided by the author into the three following classes. In the first class non-conducting porous diaphragms are used; the cell of Schmidt belongs to this type. In the second class solid partial partitions of a non-conducting material (like glass) are used, the cell of Schoop being an example. In the third class, metallic partial partitions are used, and the cells of Garruti and Schuckert are representative of this type. The author concluded his paper by some remarks on the cost and on the different uses of electrolytic hydrogen and oxygen.

In the discussion which followed, Mr. Carl Hering asked whether it would not be economical to use a high temperature, and Dr. Richards replied that 70° C. are stated to be the best voltage for the Schuckert system. Mr. Hering asked where the energy comes from, which corresponds to the expansion of the gases developed at the electrodes, whether it comes

from electrical energy or from the heat of the surroundings. Mr. C. J. Reed later explained that in his opinion the heat of the surrounding liquid must be considered to give the energy of the development of gases. Mr. Townsend Wolcott asked whether in the third type of cell with metallic partial diaphragms the current really passes through the diaphragms. This is not the case, as otherwise hydrogen and oxygen would be developed at both sides of the diaphragm. Dr. E. F. Roeber expressed the opinion that there is absolutely no new principle which distinguishes the third class (with the partial metallic diaphragm) from the second class (with the partial non-metallic diaphragm), since the partial metallic diaphragm is intended not to act as a bipolar electrode and behaves essentially like a glass plate. Dr. Richards explained that it is due to Garruti to have discovered that a metal can be used instead of glass or similar materials for the partial diaphragm, if only the e. m. f. at the terminals is kept below the value which would cause the diaphragm to act as bipolar electrode. Metallic diaphragms are, of course, preferable to glass, on account of durability. Dr. C. A. Doremus made some historical remarks on the subject.

THE THERMOCHEMISTRY OF ELECTROLYTIC DISSOCIATION.

A paper on this subject was presented by Mr. C. J. REED, of Philadelphia. This paper was essentially a criticism of Dr. J. W. Richards' paper on the same subject read before the last Niagara Falls meeting of the American Electrochemical Society (ELECTROCHEMICAL INDUSTRY, 1903, page 491). In this paper Dr. Richards considered the neutralization heat to be merely the condensation heat of water vapor from the gaseous to the liquid stat. From the circumstance that there is no quantitative relation between the formation heats and the solution and neutralization heats of compounds be concluded that ionization cannot be a destruction or dissociation of the compound and emphasized that in his opinion ions in solution are in the combined, instead of the dissociated state. In his calculations, however, he assumed that in a dilute solution of $2NaOH.400\ H_2O$ an osmotic pressure of 12.34 atmospheres is exerted by the NaOH. Mr. Reed points out that this is about twice the osmotic pressure that would be exerted if the Na and OH were combined, so that he thinks that Dr. Richards' proof that there is no dissociation in dilute solution rests upon the fundamental assumption that there is complete dissociation when he calculates the osmotic pressure. Concerning the rule given by Dr. Richards on the calculation of formation heats, he says that there is an agreement among a considerable number of compounds, particularly the chlorides of the alkali metals. As we get further away from the alkalies, and further away from the chlorides in the list, the disagreements become more marked. He says that there are many compounds whose formation heat is positive, while it would be negative according to Richards' rule. As examples in which the disagreement is great, he gives mercury bromide and silver bromide.

In the discussion which followed the paper, Dr. Richards explained that the rule for calculating the formation heats, attacked by Mr. Reed, did not originate with him, but is much older, having been formulated by Hess and Tommasi. This rule was given by Richards as applying essentially to very dilute solutions, while Mr. Reed had picked out insoluble salts for which the rule is not assumed to apply. The rule holds in general for the majority for soluble salts, although even in this case there are exceptions which are assumed by the adherents of the dissociation theory to be due to incomplete ionization. Concerning his calculation of the osmotic pressure of NaOH he emphasizes that he did not make any concession on the fundamental proposition on the dissociation theory when he assumed the osmotic pressure to be 12.34 atmospheres. He simply took this value from an analogy with other electrolytes in which the osmotic pressure in very dilute solutions has been determined. Mr. Reed replied that in his opinion there is no such thing like an insoluble compound since every compound will dissolve if one only takes enough quantity of solvent. He also referred to the disagreement between the rule and the facts in the case of cadimum iodide. To assume a double osmotic pressure is, in his opinion, to assume a double number of molecules and this is the fundamental supposition of the dissociation theory. Dr. Richards replied that it is not necessary to assume double the osmotic pressure in his calculation in order to find a value of the neutralization heat which agrees fairly well with the facts; although the agreement is better if double the osmotic pressure is used instead of single. Besides, the value of the osmotic pressure in a very dilute solution is an experimental fact and independent of any theory concerning it.

FERRO-ALLOYS.

A paper on this subject was presented by Mr. AUGUSTO J. ROSSI, of New York City, who spoke on his researches on the manufacture of ferro-alloys in the electric furnace. Since these researches are well known to our readers from Mr. Rossi's article on page 523 of our issue of November, 1903 (see also December issue, page 583), these references to our former articles must here suffice. Mr. Rossi exhibited a very interesting collection of ferro-metals, obtained electrically, and other electric furnace products, including ferro-titanium, ferro-tungsten, ferro-molybdenum, ferro-chrome, ferro-silicon, ferro-manganese, copper-titanium, with accompanying slags and other accessory products.

A STRANGE OBSERVATION.

A brief note under this title was presented by Mr. I. J. MOLTKEHANSEN, of Rahway, N. J. By electrolyzing a pretty concentrated silver nitrate solution with two platinum wires as electrodes, he obtained a deposit of silver around the end of the cathode wire, but simultaneously a deposit was formed at the end of the anode wire. He asked for an explanation. Mr. C. J. Reed suggested that if the author had not made sure that the anodic deposit was really silver, it might have been silver peroxide, which could have easily formed under the conditions of the experiment. There would, of course, be nothing strange about that. Mr. Moltkehansen replied that he had not analyzed the anodic deposit.

After the by-laws of the local section had been adopted the meeting adjourned. Another meeting will be held during Spring.

# SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

*A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.*

INDUSTRIAL ELECTROCHEMISTRY.

*Sterilization of Water by Ozone.*—A paper on this subject by ERLWEIN (who, as chief engineer of the electrochemical department of Siemens & Halske in Berlin, has had considerable experience in this field) is published in the *Zeit. f. Elektrochemie*, January 1. The investigations by Siemens & Halske, Ohlmueller-Prall, Proskauer and Schueder, as well as the results obtained on a commercial scale in Wiesbaden and Martinikenfelde, show that ordinary germs are reduced by ozone to a smaller number than is generally possible in the best filtration plants, while the germs of cholera morbus, typhoid, etc., are always destroyed. He states that an estimate of the cost shows that the fuel consumption, i. e., the cost of energy for making ozone, is only a relatively small percentage of the

total cost per cubicmeter, and that under favorable conditions the method of purifying water by ozone is able to compete in cost with sand filtration. The calculations are based on a consumption of ozone of 2 grams per cubicmeter, which should always be sufficient, except in special cases. In Paderborn and Wiesbaden 1 to 1.2 grams are consumed per cubicmeter. In Figs. 1 and 2 the diagrams of the different systems of sterilizing and ozonizing apparatus are given. (For details the following references are given: Zeit. f. Elektrochemie, v. 7, p. 788; Tindal, Annales de l'Institut Pasteur, September, 1895; Revue générale des Sciences, July 17, 1896; Abraham-Marmier, Bulletin de la Société Internationale des Electricians, v. 17, No. 172, 1900; Otto, La Nature, 1899, No. 1377 and L'Industrie de l'ozone, extrait des mémoires de la Société des Ingenieurs Civils de France, February, 1900; Vosmaer, Zeit. f. Elektrochemie, v. 8, No. 30, 1902; Siemens & Halske, Elektrotechnische Zeit., v. 12, p. 340, 1891; Jour. f. Gasbel. u. Wasservers, 1901, Nos. 30 and 31, and 1902, No. 40, by Erlwein).

Daily Operation, About 12 Hours.

Cost of Operation for Ozonizing Plants for Treating 2000 and 200 Cubicmeters per Hour.

| | Steam Power. | | Steam Power. | | Generator Gas Power. | |
|---|---|---|---|---|---|---|
| Output per hour | 2 000 cbm | | 200 cmb | | 200 cbm | |
| Output per year | 9,000,000 cbm | | 900,000 cmb | | 900,000 cbm | |
| Power | 275 hp | | 45.5 hp | | 45.5 hp | |
| Energy per year | 1,237,500 hp hours | | 204,800 hp hours | | 204,800 hp hours | |
| Yearly cost of operation— | | | | | | |
| a. 4% interest | 162,500×0.04=$6,500 | | 50,000×0.04=$2 000 | | 50,000×0.04=$2,000 | |
| b. 3% amortization | 162,500×0.03= 4,875 | | 50,000×0.03= 1,500 | | 50,000×0.03= 1 500 | |
| c. Cost of fuel | $4,250[1] | | $1,383[2] | | $725[3] | |
| Wages and cost of maintenance | 3,125 | | 1,367 | | 1,275 | |
| Total yearly cost of operation | 18,750 | | 6,250 | | 3,500 | |
| Cost per cubic meter of water— | | | | | | |
| a. 4% interest | 0 072 cent | 0.126cent | 0.22 cent | 0.39 cent | 0 22 cent | 0.39 cent |
| b. 3% amortization | 0.054 " | | 0.17 " | | 0.17 " | |
| c. Cost of fuel | 0.047 cent | + | 0.15 cent | + | 0.08 cent | 0.22 cent |
| d. Wages and cost of operation | 0.035 " | 0.082cent | 0 15 " | 0.30 cent | 0.14 " | |

[1] Coal consumption 0.8 kg per hp hour; coal price $4.25 per ton.
[2] Coal consumption 1.6 kg per hp hour; coal price $4.25 per ton.
[3] Anthracite consumption 0.61 kg per hp hour; anthracite price $5.60 per ton.

In Figs. 1 and 2 the upper series of pictures represents the different sterilization apparatus. I is the older Siemens iron tower for pressing ozone through the water; I[1] is the tower, now used, which is 4 meters high and filled with stones; II is the tower of Tindal, which is 8 to 10 meters high, and in which the ozone passes through a series of rain showers between cylinders with sieve bottoms; III is the tower of Abraham-Mermier, of about 4 meters height, the details of which are not yet known; IV the Otto tower in two parts, in which the water is mixed with ozone in the upper part, while in the lower part ozone passes again through the ozonized water while it passes through stones; V is the tower of Vosmaer (Electrochemical Industry, September, 1902, p. 31).

The lower row of diagrams represents the various ozonizing apparatus. Ia is the ozonizer of Siemens & Halske, using glass as dielectrics, cylindric discharge surfaces and water-cooling of the external earthed electrode; it is operated by 8000 volt alternating current. IIa is the 40,000 to 50,000 volt ozonizer of Tindal, with metal plates as discharge surfaces without a solid dielectric, the earthed electrode being water-cooled. IIIa is the ozonizer of Abraham-Marmier, characterized by a series of several glass plates of 1 square meter size, as discharge surfaces; the voltage is 40,000. IVa is the ozonizer of Otto, which is operated at 20,000 volts, without dielectrics. The details of the ozonizer of Vosmaer are unknown; it is stated to be operated at 10,000 volts without a solid dielectric.

*Diaphragm Process for the Electrolysis of Chlorides of Alkalies.*—In the August and September issues of the *Journal de Chimie Physique*, P. A. Guye gives an account of an extended investigation of the electrolysis of the chlorides of alkalies in diaphragm cells. In reality the problem is a very complicated one, since, after electrolysis has been going on for some time, we get, not only the primary products of electrolysis; namely, chlorine and hydroxide, but also hypochlorites, chlorate, oxygen, etc.; the phenomena are still more complicated by diffusion and endosmosis (cataphoresis). The investigation is, however, greatly simplified, if the matter is looked upon from the point of view of Hittorf, and if we assume that we have essentially a solution of chloride in the anodic compartment, and a solution of chloride and hydroxide in the cathodic compartment. In the latter mixture, both the chloride and the hydroxide participate in transporting the current, according to their electric conductivities. If there was only NaOH in the cathodic compartment, for each 96,540 coulombs, passing through the cell, one gramion of Na is discharged at the cathode, and 1 grammolecule NaOH is formed, at the same time $n$ grammolecules NaOH would pass into the anodic compartment ($n$ representing the transport number of OH, a figure between 0 and 1); in other words the contents of hydroxide in the cathodic compartment would increase by $1-n$ grammolecules NaOH. But in reality we have in the cathodic compartment a mixture of NaCl and NaOH, and when 1 gramion Na is discharged, ($1-x$ grammolecules of NaCl and $x$ grammolecule NaOH transport the current. Hence, only $n\,x$ grammolecule of NaOH are carried out of the cathodic compartment, so that $1-n\,x$ grammolecules NaOH are formed in the cathodic compartment for every 96,540 coulombs passing through the cell. This value $r = 1-n\,x$ is called by the author the "instantaneous output of the current," where $n$ is Hittorf's transport number (a known figure) and $x$ depends on the electric conductivities of NaCl and NaOH at the concentrations in which they exist in the cathodic mixture. In general $r$ (which is a value between zero and unity) depends upon three quantities: the concentration of the chloride, the concentration of the hydroxide, and the temperature. But since commercial cells are generally operated at a constant temperature, the latter is no longer a variable quantity. Moreover, any diaphragm cell is worked by one of the following two methods. Either the cathodic liquid is maintained saturated with sodium chloride, so that its concentration is no longer variable and the "instantaneous output" $r$ is a function of only the concentration $c$ of NaOH. The second method is not to add anything to the cathodic compartment during electrolysis, but to start with an initial concentration of NaCl, which becomes smaller and smaller the more the concentration of NaOH increases, but in this case the concentration of NaCl depends necessarily on the concentration of NaOH, so that the instantaneous output $r$ is again a function of only the concentration $c$ of NaOH. The diffusion of NaCl from the cathodic to the anodic compartment is counterbalanced by the opposite transference of NaCl, due to electric endosmosis (cataphoresis). Hence, in general $r$ may be set $= f(c)$. He has found that for the first of the above-mentioned cases in which the concentration $c$ of the sodium chloride is maintained constant, the instantaneous output may be represented by the formula $r = \frac{1}{(1+ac)^{1/2}}$ and in the second case in which the concentration of NaCl decreases at the same time, as NaOH increases, the formula is $r = \frac{1}{1+ac}$

These formulas enable the author to simplify all further calculations. It appears that all the different secondary phenomena, mentioned in the introduction have no important influence on the production of caustic alkali, and that, in order to calculate the latter, it is sufficient to base all calculations on the "instantaneous output" $r$. By neglecting all other phenomena, one can predetermine with sufficient exactness the whole opera-

tion of a diaphragm cell under the two conditions of working mentioned above. The author gives an account of a series of measurements which prove the correctness of his theory.

*Rapid Electrodeposition of Copper.*—To deposit a metal from a solution by the electric current, it is necessary that the metal ions are present in sufficient number at the cathode. If a comparatively high cathodic current density is used, the danger is that the electrolyte in proximity to the cathode becomes poor in the ions to the deposited, and other processes start, especially the development of hydrogen. To counteract this tendency, it is necessary to artificially bring fresh electrolyte to the cathode surface, as, for instance, by means of stirring, rotating the cathode, etc. To impinge or inject the electrolyte against the cathode, has naturally the same effect, and a number of patents have been granted for such methods. These are summarized in an article in the *Electrochemist and Metallurgist*, of November, in which the methods of Thoffern, Grahams, Poore Dessolle and Harrison are briefly described and partly illustrated by diagrams.

THEORETICAL AND EXPERIMENTAL.

*Action of Sodium and Potassium Amalgams on Various Aqueous Solutions.* A long paper on this subject by FERNEKES is published in the December issue of the *Journal of Physical Chemistry*. Following the researches of Kahlenberg on the action of magnesium upon different aqueous solutions, the present author has studied in a similar way sodium and potassium, but on account of the violence of the reaction between these metals and water, and since these metals are so easily oxidized, their amalgams were used. A full account is given of the experimental work, and the results are summed up in tables and diagrams. If one makes use of the convenient term catalytic action, it is possible to classify all the reactions under two heads. First, there are those substances, which, dissolved in water, retard the action of the amalgam so that the speed with which the latter liberates hydrogen, is less than with pure water. These substances are "negative catalytic agents," and include most of the salts of the inorganic acids, also some organic compounds. Then there are those substances which

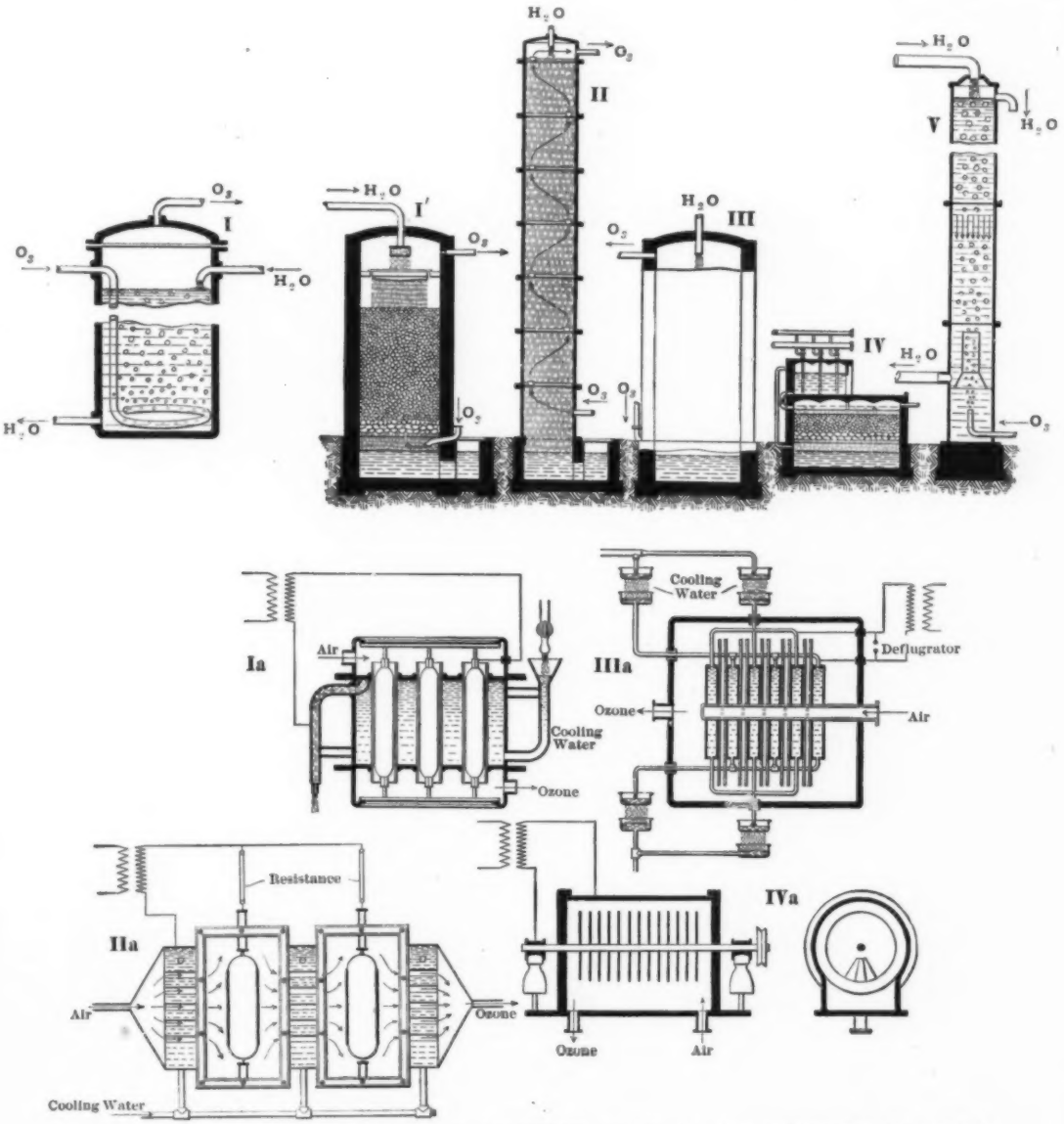



FIG. 1 AND II.—WATER STERILIZATION APPARATUS (I. TO V.) AND OZONIZERS (Ia TO IVa).

in solution increase the action of the amalgam. They are "positive catalytic agents," and include most of the organic substances employed, especially the hydro-carbons. The term catalytic action does not give an explanation of these phenomena, but merely serves as a convenient term for classification. The paper is of special interest, for the reason that the author tries to give an explanation on the basis of Kahlenberg's theory of chemical affinity between solvent and dissolved substance, in contradiction to the electrolytic dissociation theory.

According to Arrhenius, the slow action of sodium amalgam on a solution of sodium salts, is due to ions of sodium in solution, which by mass action would prevent the entrance of more sodium ions into solution. But this hypothesis fails to explain the slow action of the same amalgam on a solution of potassium salts. Chemical affinity, the affinity between solvent and dissolved substance, and the formation of a true chemical compound whose properties are different from either constituent, form the basis of the new theory. In the light of this theory, potassium chloride has about the same affinity for water as has sodium chloride, on account of the similarity of the two salts. The water in each case is held with the same degree of tenacity, and the action of the sodium amalgam on the new compound suffers an equal retardation in both cases. Concerning the majority of the organic substances investigated ("positive catalytic" agents), he remarks that as they are considered undissociated in aqueous solution, the ions cannot be held responsible for the peculiar behavior of these solutions on sodium amalgam. He assumes again the formation of a new compound, which must, in this case be extremely unstable toward sodium amalgam, since the action is more rapid than with pure water. The assumption of such unstable compound is nothing extraordinary. Numerous instances of the great reactivity of such unstable compounds are known. As an example, is mentioned that nitrous oxide is a more reactive compound than either of the elements of which it is composed. A splinter of wood will burn even more violently in nitrous oxide than in pure oxygen. Since the rate of action of the solutions on the amalgam is not proportional to the number of dissolved molecules, it appears that the first particles of the substance going into solution are attracted more strongly by the water than are the particles which enter when the solution is already partially saturated. The firmness with which the particles are held by the water diminishes with increasing concentration. The author concludes by saying that to solve the nature of catalytic reactions is one of the most important problems of modern chemistry. Catalysis plays an important role, not only in pure science, but also in many branches of chemical industry. The manufacture of indigo from naphthalene, and the manufacture of sulphuric acid are two of the numerous reactions, termed catalytic. The author says that many of these catalytic reactions find a ready explanation by the application of Kahlenberg's theory, and by using the term solution in the broad sense, which includes solid, liquid and gaseous solutions, it is thought to be not improbable that all catalytic reactions can be explained satisfactorily. It is then simply the attraction between solvent and dissolved substances and the formation of a true chemical compound which is more or less stable, and which may be made up of more than two substances, which is set down as the cause of the different rates of reaction.

*Iron Salts in Voltameter Solutions.*—The presence of iron in the sulphuric acid solution of an oxy-hydrogen voltameter has been shown by Elbs to decrease materially the amount of gas evolved. He points out that elements which have two different valencies should be eliminated from the solution of such a voltameter, because otherwise successive reduction and oxidation take place, reduction of ferric to ferrous sulphate at the cathode and oxidation at the anode. The actual amount of gas evolved depends on various conditions: On the rate of diffusion of ferrous salt to the anode, and ferric salt to the cathode, on the current density, and on the cencentration of iron in the solution. The effect of a low current density is to cause a larger decrease in the gas product. In a paper by Bell, published in the December issue of the *Journal of Physical Chemistry*, attention is called to the fact that according to experiments of Schwab and Baum, the effect of iron in the solutions of a copper voltameter is practically negligible. The two sets of experiments, the one by Elbs, and the other by Schwab and Baum, are comparatively contradictory, but they have one essential difference. In the oxy-hydrogen voltameter, platinum electrodes are used, while in the copper voltameter there is a soluble anode. The oxygen which appears at the anode in the first case oxidizes ferrous sulphate to ferric sulphate, while in the second case copper goes into the solution. The amount of gas evolved in the first case is further diminished, because of the reducing action of hydrogen on the ferric sulphate. In the second case no ferric sulphate is produced except by oxidation by the air, the rate of which oxidation is quite low. Two experiments are described to prove that the two cases are not contradictory.

*Radio Activity.*—It is difficult to follow closely all the new investigations concerning radio activity. Those who are interested in a concise and authoritative summary of recent researches on this subject may be referred to an article of Curie, published in the December issue of the *Journal de Chimie Physique*. The author discusses the subjects under the following headings: Radioactive substances; the different radiations given off from radioactive substances; heat developed by the salts of radium; induced radioactivity and radioactive emanations. The article is concluded by a list of recent literature on the subject.

### Batteries.

*Edison Nickel-Iron Battery.*—While nothing so far has been published in this country on details of manufacture of the active materials used in the Edison iron-nickel accumulator, some information on this point is given by Janet in a paper read before the International Society of Electricians in Paris, as noticed in the London *Electrician*, December 25. The mixture of iron and protoxide of iron which constitutes the active material of the negative electrode was obtained by passing a current of hydrogen over pulverized sesquioxide of iron, $Fe_2O_3$, at a certain temperature, which Edison himself has said ought to be 480° C. The reduced iron is then very slowly cooled in a current of hydrogen and washed in water; it thus loses its property of igniting, or at least of oxidizing, when exposed to air. The mixture of iron and protoxide of iron, rich in protoxide, is a bad conductor, but conductivity was formerly imparted to it by the addition of small pieces of graphite, to the extent of 1 to 4, and from this mixture rectangular briquettes were formed under a pressure of 4300 pounds per square inch. Now, however, graphite has been abandoned in connection with the active iron material, and a different process of manufacture is employed. The iron is not raised to quite so high a temperature, and, therefore, probably contains less protoxide; it is then mixed with ammoniated copper and oxide of mercury, and, the iron reducing the compounds, there is finally obtained a mixture containing 64 per cent of iron, 30 per cent of copper, and 6 per cent of mercury. Each particle of this mixture is, according to Edison, made up of a grain of iron covered by a porous envelope of copper amalgam, in a very finely divided state, together with a small quantity of an oxide of iron.

### Miscellaneous.

*Metal and Mineral Production of the United States in 1903.*—Following its well-known custom, the *Engineering and Mining Journal* presents in the January 7 issue a great amount of valuable statistical information on the year 1903, with special reviews of different metallurgical industries and metal, mineral and chemical market. From these statistics the following table of the output of different materials in 1903 in the United States is extracted:

| | Production in 1903. | Value. |
|---|---|---|
| Aluminium | 7,500,000 lbs. | $2,325,000 |
| Copper | 670,880,000 lbs. | 88,334,770 |
| Gold | 3,600,645 troy oz. | 74,425,340 |
| Pig Iron | 17,942,840 long tons | 265,554,032 |
| Lead | 289,030 short tons | 24,492,462 |
| Nickel (from Canadian and New Caledonian ores) | 11,200,000 lbs. | 4,872,000 |
| Quicksilver | 29,103 flasks | 1,295,083 |
| Silver (from domestic ores) | 56,519,795 troy oz. | 30,520,688 |
| Zinc | 156,318 short tons | 16,282,344 |
| Arsenic | 500 short tons | 35,400 |
| Bauxite | 40,700 short tons | 179,080 |
| Carborundum | 4,724,000 lbs. | 472,400 |
| Coal, bituminous | 283,406,691 tons | 334,056,034 |
| Coal, anthracite | 73,390,000 tons | 150,449,500 |
| Coke | 25,200,000 short tons | 56,700,000 |
| Cobalt Oxide | 18,800 lbs. | 42,300 |
| Copper Sulphate | 38,773,944 lbs. | 1,628,516 |
| Copperas | 20,700 short tons | 134,550 |
| Fluor-spar | 29,300 short tons | 149,500 |
| Graphite, crystalline | 4,177,020 lbs. | 154,549 |
| Graphite, artificial | 1,988,000 lbs. | 160,479 |
| Lead Pigments: | | |
| White Lead | 112,700 short tons | 12,228,024 |
| Red Lead | 12,300 short tons | 1,385,900 |
| Litharge | 12,400 tons | 1,326,800 |
| Orange, mineral | 1,000 short tons | 168,000 |
| Limestone Flux | 9,509,790 long tons | 5,307,310 |
| Phosphate, rock | 1,477,601 long tons | 5,328 018 |
| Pyrites | 196,970 long tons | 778,031 |
| Sulphur | 12,054 long tons | 262,175 |
| Zinc white | 59,810 short tons | 5,005,394 |
| Zinc Ore (exported) | 37,619 short tons | 932,724 |
| Zinc Lead Pigment | 4,500 short tons | 253,125 |

*Iron and Steel Alloys.*—The first issue (January, 1904) has appeared of the *Iron and Steel Metallurgist*, which is an outgrowth of the Metallographist. Besides the portrait of Prof. Howe, and various other articles and reviews, it contains an illustrated article by HADFIELD, the well-known pioneer in the field of iron and steel alloys. He discusses briefly the properties of carbon steel and the alloys of iron and manganese, silicon, aluminium, chromium, nickel, tungsten, cobalt, copper, titanium, molybdenum, vanadium. Since he discusses the properties of these alloys very concisely, his remarks cannot be briefly abstracted, but it may be noticed that he does not seem to entertain great hopes for especially good results from the rare metals. For instance, concerning the alloys of iron and vanadium, he says that "It is claimed that this metal greatly increases the elastic limit, but it is doubtful whether this is so, except in the presence of carbon; that is, its action is not unlike that of chromium, though lesser percentages are stated to give the same effect as the latter metal. In view of its even now very high first cost, why use so expensive an element when a much cheaper one, such as chromium, appears to answer the same purpose? The writer has produced steel containing nickel and chromium that gave higher elastic limit and tenacity, also comparatively higher elongation than shown by results of iron with vanadium." Concerning alloys of iron and silicon, he says that experiments which may prove of extreme importance regarding the effect produced by silicon upon the magnetic properties of iron are in progress. A summary of the properties of the different alloys is given in form of tables and diagrams. At the conclusion the author remarks that he has produced alloys with tensile strength all the way from 18 tons up to 110 tons per square inch, and with elongations from nil to 70 per cent, but, singular, as it may seem, notwithstanding the important part played by all these new iron alloys, carbon steel maintains its premier position in determining the practical field of the various products. In other words, there are few, if any, iron alloys in which, apart from the effect produced by the special element added, the presence of carbon is also unnecessary. Therefore, whether one is a carbonist or allotropist in theory, one has to admit that carbon alone is the predominant factor in determining the utility of the alloy.

*Color Photography by Electrolytic Means.*—In an article published in the *Zeit f. Elektrochemie*, November 19, RIEDER calls attention to the fact that thin anodic deposits often show very beautiful colors. He has tried to utilize this phenomenon in connection with the problem of photography in colors, and describes a series of preliminary experiments, which he has made in this direction. The methods used by him are described in detail, but the gist of them is that he first produces a picture on a sensitive plate, and then brings the plate as anode into an electrolytic cell. He really thus produces beautiful colors, but it is a pity that the colors are not those which they should be. He gets, for instance, blue where he ought to get red, and it seems that it is not always certain what colors one gets by such a method.

*Anti-Friction Metal.*—The same author, RIEDER, describes in the *Elektrotechnischer Anzeiger*, of December 13, an anti-friction metal consisting of graphite grains embedded in copper. If a copper surface in which copper graphite grains are embedded, rubs against another metallic surface, then the wear and tear takes away, not only the copper, but also graphite, and the graphite, by coming between the two rubbing surfaces, diminishes the friction and counteracts the wear and tear. He thinks this copper-graphite metal to be suitable for various purposes; for instance, for dynamo brushes. The method of producing this anti-friction metal is an electrolytic one. In a mould, the surface of which is made conducting, a layer of graphite grains (the best for this purpose are said to have the size and irregular form of carborundum No. 30) is placed, and copper is deposited electrolytically, so as to fill the spaces between the grains; after these are filled up, another layer of graphite grains is placed upon the first one and electrolysis is continued, etc.

*Bitumen in Insulating Compositions.*—The December issue of the *Electrochemist and Metallurgist* contains SUTHERLAND'S full paper on this subject, an abstract of which was given on page 4 of our January issue.

*Chemistry of Explosives.*—In a paper published in the *Zeitschrift f. Elektrochemie*, January 1, WILL gives an historical sketch of the progress made in the chemistry of explosives in connection with the development of organic chemistry.

# ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

*Process of Manufacturing Alkali Cyanides.*—P. Dankwardt, Deadwood, S. D. Patent 746,795, December 15, 1903. Application filed June 10, 1903.

The process consists in heating a mixture of an alkaline earth nitride, preferably magnesium nitride, an alkali salt, and an alkaline earth carbide, in the electric furnace. The latter is water-jacketed, and two electrodes are introduced into it, passing insulated through opposite sides of the furnace. Pipes are arranged above the electrodes for the purpose of supplying gaseous nitrogen to the interior of the furnace. The ingredients which compose the charge are mixed in about the following proportions by weight: 100 parts of magnesium nitride, 85 parts of sodium fluoride, and 65 parts of calcium carbide.

This mixture is charged into the furnace until the latter is filled above the nitrogen supply pipes. The remainder of the charge is composed of 85 parts of fluoride of sodium, and 65 parts of calcium carbide. After the current is put on, nitrogen is introduced into the furnace. The reaction between the constituents of the charge is expressed by the formula:

$$Mg_3N_2 + 2NaFl + CaC_2 = CaFl_2 + 2NaCN + 3\ Mg.$$

The magnesium vapors react with the nitrogen and reform magnesium nitride, which again interacts with a fresh portion of the charge. It is important to have no oxidizing substances present in the constituents of the charge, or in the gas introduced, as they will lower the yield of sodium cyanide considerably, owing to the formation of alkaline carbonate, instead of the cyanide. The product, consisting of a mixture of sodium cyanide and calcium fluoride, is drawn from the furnace through a tapping hole, and the mixture either sold as such, or refined into pure cyanide.

*Process of Simultaneously Producing Alkali Cyanide and Alkali Metal.* Paul Dankwardt, Deadwood, S. D. Patent 746,796, December 15, 1903. Application filed June 10, 1903.

The inventor proposes to heat a mixture of the nitrite of an alkali metal with another alkali metal salt, and the carbide of an alkaline earth metal, under exclusion of the air. He prefers to use sodium nitrite and carbide of calcium, while the other alkali salt may be any salt which does not contain oxygen. The operation is carried on in a water-jacketed electric furnace, the two electrodes of which are introduced opposit each other, a short distance above the bottom of the furnace. The latter is provided with a tapping hole and an outlet pipe, which carries the metallic vapors to a receptacle. The charge is made up of 138 parts, by weight, of sodium nitrite, 195 parts of sodium fluoride, and 255 parts of calcium carbide. The reaction is stated to be,

$$2NaNO_2 + 3CaC_2 + 6NaFl = 2NaCN + 4CO + 6Na + 3CaFl_2.$$

Sodium sulphide may be used instead of the sodium fluoride, in which case calcium sulphide is formed. The fused mixture of the cyanide and fluoride, or sulphide, is withdrawn from the furnace by the tapping hole, while the alkali metal volatilizes and passes into the receptacle mentioned above.

*Manufacture of Sodium.* Thomas Ewan, Glasgow, Scotland, assignor to the Cassel Gold Extracting Co. Patent 745,958, December 1, 1903.

The inventor proposes to electrolyze caustic soda in a vessel, which is heated from the outside, and which is provided with a diaphragm. The latter is made of alumina, which will combine with the caustic soda to form sodium aluminate, or it is made of sodium aluminate in the first place, its structure in either case being that of unglazed porcelain. The inventor claims that when fused caustic soda is electrolyzed, sodium, together with a small quantity of hydrogen, is formed at the cathode, while oxygen and water are formed at the anode. He concedes that previously to this invention sodium has been made by the electrolytic decomposition of sodium hydroxide on a manufacturing scale, but claims that usually the water formed at the anode has been allowed to remain in the electrolyte. Under these circumstances he claims that the whole, or a larger portion of the water reacts with the sodium separated at the cathode, thereby reconverting about one-half of it into sodium hydroxide. By his invention, however, the water is isolated in the portion of the electrolyte surrounding the anode, from which it evaporates as quickly as it is formed, and this may be precipitated by passing a current of air over or through the electrolyte in the anode compartment. He omits, however, in propounding this novel theory of the electrolysis of fused caustic soda, to state where the water, which he claims is formed at the anode, is to come from. Blowing air through or over the caustic melt would result in the formation of a good deal of carbonate with consequent thickening of the melt.

### Apparatus and Processes for the Electrolytic Production of Metals and Compounds.

*Bleaching Process.* M. Ruthenburg, Harrisburg, Pa. Patent 747,234, December 15, 1903. Application filed February 14, 1902.

The process described in the specification is intended for bleaching substances such as paper pulp and like materials. The stuff to be treated is mixed with an aqueous solution containing 20 per cent sodium chloride, in such proportion that the material is not only thoroughly impregnated with the solution but is also brought to such a consistency as to travel readily through the apparatus. The apparatus consists of a rectangular vessel, into which the electrodes are suspended from above, openings being provided in the cover for that purpose. A series of plates is disposed on the bottom of the apparatus, the plates being arranged midway between the electrodes. The terminals of the source of current are connected to the first and the last of the series of electrodes. It has been found advantageous to mix with the above solution of sodium chloride a solution which contains 10 per cent of hydrated oxide of calcium the object of the latter being to take up any chlorine liberated from the sodium chloride. Satisfactory results are stated to have been obtained by exposing the saturated material to be treated for approximately five minutes between electrodes, the current density at which was one-half ampere per square inch of electrode surface exposed to the mixture, at a pressure of 3 volts. The material to be treated is moved through the apparatus by a pump or other convenient means and in its progress it comes into contact with the surfaces of the electrodes.

*Electrode.* H. Blackman, New York. Patent 745,412, December 1, 1903. Application filed December 8, 1896.

The specification describes a mechanical construction for electrically and mechanically connecting the electrodes and keeping them properly spaced apart in the electrolyte, providing also for a possibility of readily removing any one electrode without disturbing its neighbors. For the purpose of keeping the electrodes apart, stops or buttons of glass or porcelain are provided which are formed as short screws adjustable and preferably applied to the cathode. For the purpose of protecting the electrodes from corrosion near the surface of the electrolyte, each of them is provided with a band or layer of glass or vitreous glaze. The electrodes are provided with arms or elbows, which rest upon the respective bus-bars and are held to them by a clamp of special construction. The iron anode plates are formed by casting or forging, and are then exposed to oxidizing agents under such conditions as to convert the exterior portion into magnetic oxide of iron, the treatment being continued until the oxide is of sufficient thickness to be impermeable to the chlorine set free during the electrolysis, the electrodes being primarily intended for use in the elctrolysis of sodium chlorid.

*Apparatus for Refining Metals.* A. Schwarz, New York, Patent 746,748, December 15, 1903. Application filed April 10, 1903.

The specification describes an arrangement for the refining of metals, in which the refining tanks are arranged in tiers in such a manner that the solution containing the metal to be refined flows from the lower part of the upper tanks into the next lower series of tanks. In order to obtain a rapid circulation of the electrolyte, and yet not be disturbed by the consequent stirring up of the slimes, the inventor interposes filters between the upper and the lower tanks through which the solution has to pass and which retain the slimes with which it is charged. The refining tanks are constructed preferably of wood, double-walled, the space between the two walls being filled with pitch or other suitable material. Each tank is provided with means to procure a constant flow of solution and rests in a trough-like support, in which filters are located below the outlet valve from the tank. The bottoms of the tanks are made V-shaped, so that the electrodes do not rest upon the bottoms. From the

last row of tanks the solution flows into a heating tank whence it is raised by a pump to pass again through the tanks. It is claimed that the electrolytic action is facilitated by reason of the rapidity of circulation of the solution and that the latter is kept free from slimes, with the effect of producing an even and increased deposit of metal.

*Method of Finishing Metal Articles.* Charlotte R. Manning, Meriden, Conn. Patent 746,724, December 15, 1903. Application filed January 5, 1903.

The invention relates particularly to finishing the surfaces of porcelain or enamel-lined vessels the object being to prevent their scaling off, when the lining of the vessel is fired in order to harden it. The invention is carried out by first polishing the exterior of the vessel which is to be treated and then giving it a coat of nickel copper or other material by electroplating. The interior of the vessel is then given an enamel lining, and the vessel is fired to set the lining. After the firing the exterior surface is removed with a grinding or polishing wheel, or by acids, and polished for the final finish of nickel, silver or other material by electroplating. The first coating so protects the exterior surface that no scales are formed.

### STORAGE BATTERIES.

*Battery Element.* C. B. Schoenmehl, Waterbury, Conn. Patent 737,285, August 25, 1903. Application filed May 19, 1902.

The object of the invention is to secure a battery electrode which will give the greatest amount of power and life. The electrode is preferably formed of oxide of copper, which is first mixed with suitable solutions and then compressed or molded into shapes which have a wedge-shaped cross-section, being thickest at the top and tapering down to a narrow edge at the bottom. After being molded, the electrode is solidified by being compressed and baked.

*Galvanic Battery.* C. B. Schoenmehl, Waterbury, Conn. Patent 737,286, August 25, 1903. Application filed May 1, 1903.

The inventor proposes to construct copper oxide electrodes in the form of an annular body, thickest at the top and tapering toward the bottom. Several shapes of electrodes, which embody this idea, are given.

*Dry-Cell Battery.* E. R. Gill, New York. Patent 738,025, September 1, 1903. Application filed December 20, 1901.

The inventor emphasises the difficulty of filling in the powdered compound which constitutes the electrolyte of dry cell, in such a manner that it is not packed too tightly nor too loosely. In the first case there is not sufficient room for the gases to escape and the cell is liable to burst, while in the second case the internal resistance is too great. The inventor claims to secure an advantageous result, by first filling the cell with the powdered electrolyte, applying moderate pressure, and then forcing a pointed electrode into the center. The preferred form of electrode looks like a rod with a tapering screw thread, but it may only be plain point or conical. When the electrode is in position, the cell is closed in the usual manner by a suitable sealing material.

*Electric Storage Cell.*—J. A. Lyons and E. C. Broadwell, Chicago. Patent 744,216, November 17, 1903. Application filed January 26, 1903.

The object of the inventors is to provide a light and cheap accumulator cell, and for this purpose they propose to employ a metallic containing jar as cathode, and a porous body of carbon, placed inside of the latter, as anode. The jar is filled with either a paste of ground or granular carbon and lead chloride, bromide or iodide, or a solution of the chlorides, bromides or iodides of zinc, cadmium, cobalt, nickel, iron, tin or copper. The inventors state that they take advantage of the fact that charcoal, when compact, is able to condense and retain within its pores about 200 times its volume or three-quarters of its weight of chlorine gas and a larger quantity of liquid bromine. The carbonaceous anode is intended to form a carbonaceous wick to "support bromine against gravity," or to condense chlorine. In practice the inventors prefer the haloid salts of lead, cobalt, nickel, cadmium or zinc. They state that electrolysis of such salts as named above has been mostly operated to obtain the metals and halogens as such, or for chemical transpositions, and not "for the emplacement of the ions in such manner as to return by their recombination as kinetic energy the potentiality endowed by their disassociation by electrolysis." Salts, like chloride of calcium or sodium, or the nitrates of these metals are added in order to increase the conductivity of the electrolyte, without interfering in any way with the mechanism of the electrolytic action.

*Accumulator Plate or Grid.* J. von der Poppenburg, Charlottenburg, Germany. Patent 743,188, November 3, 1903. Application filed May 13, 1903.

The plate consists essentially of a grate-shaped current conductor, which comprises two straight longitudinal bars with a number of transverse bars. The central portion of the transverse bars, i. e., the portion comprised between the two straight longitudinal bars, is flat, while the projecting ends are slightly curved or bent. A frame is provided which has a series of recesses just opposite the free ends of the transverse bars. The grid is laid on the frame and the curved ends of the bars bent flat so that they slip into the recesses of the frame and thus firmly secure the grating to the frame. The active material is then applied to the frame in a suitable manner.

*Battery Grid.* G. H. Rabenalt, Buffalo. Patent 743,102, November 3, 1903. Application filed November 5, 1902.

The object of the invention is to arrange a grid in which the active material is securely held, and to maintain contact between the grid and the active material at all times regardless of the shrinking of the latter. The grid is therefore constructed of outside bars with a number of intermediate bars, so as to form a number of compartments. Each compartment is provided with an anchoring device relatively thin and constructed with projecting parts, which are intended to be imbedded in the active material. As the spongy lead shrinks and draws away from the outside bars or the cross-bars in the several compartments it contracts and closes tightly around the anchoring devices and is thus maintained in intimate electrical contact with them. Means are also provided for holding the marginal and corner portions of the active material intact and preventing their breaking off from the grid.

*Secondary Battery.* G. K. Hartung, New York. Patent 754,604, December 1, 1903. Application filed September 16, 1903.

The battery element described in the specification is composed of a series of tubes of porous earthenware, each tube containing the material to become active. The latter consists usually of an oxide of lead, mixed with resilient sub-divided inactive material, such as finely divided cork or pure rubber. The tubes are supported in a frame consisting of two strips which are clamped together and thus hold the tubes. In the center of each tube there is a rod of conducting material, the tubular elements being divided into two series alternating with each other, the rod of each series being connected to a metallic conductor. The tubular elements are thus divided into positive and negative elements. The compound element thus formed is immersed in an electrolyte, such as sulphuric acid and water and placed in an enclosing cell.

*Storage Battery.* Rufus N. Chamberlain, Depew, N. Y. Patent 746,289, December 8, 1903. Application filed May 13, 1901.

The invention relates to means for regulating the temperature of storage batteries, the object being attained by arranging a horizontal lead coil on the bottom of each cell below the electrodes, the coil being preferably separated from the bottom by a sheet of asbestos. Steam is used for heating the coil, and cold water is introduced for the purpose of cooling the contents of the cell whenever it is necessary. An insulated tubular coupling is interposed between the outlet pipe of one coil, and

the inlet pipe of the next following coil, for the purpose of allowing the heating or cooling medium to flow from one coil to the other without making a metallic connection between the coils.

*Secondary Battery Separator.* Hugh Rodman, Philadelphia. Patent 747,892, December 22, 1903. Application filed May 17, 1902.

The inventor has discovered that where wooden separators come in contact with the peroxide or active material of the positive plate the nascent oxygen causes deleterious rotting of the wood. The object of the invention is, therefore, to provide a wooden separator with ribs projecting from a central sheet, and to interpose a perforated sheet of rubber between the positive pole plate and the separator. The term "wooden" in the specification is intended to include also such materials as paper and other cellulose fiber products.

### Galvanic Elements.

*Galvanic Cell.* W. Strickland, Brighton, England. Patent 742,365, October 27, 1903. Application filed July 23, 1903.

The invention relates to a cell which may be kept in an inactive state without deterioration and rendered active when it is desired to use it. It consists of a cylindrical receptacle, containing a carbon rod, surrounded by a mixture of manganese peroxide and Ceylon graphite, covered with several layers of a cotton material. The negative electrode is a cylindrical zinc plate, also surrounded on both sides by a layer of a similar cotton material. The upper part of the cell is filled with a dry powdered mixture of forty parts ammonium chloride, ten parts calcium chloride, five parts mercury sulphate, and twenty-five parts silver sand, all by weight. The whole is then covered with a layer of pitch, a vent hole closed by a stopper being left. When it is desired to render the element active this stopper is removed and water poured into the element.

*Primary Battery.*—J. A. Pedrazzi, Carmel, Cal. Patent 742,726, October 27, 1903. Application filed July 16, 1903.

The cell contains a zinc electrode, a porous cup and a copper electrode in a glass jar. The zinc electrode is formed of corrugated sheet zinc bent into cylindrical shape, the corrugations serving to hold the porous cup. The copper electrode is specially constructed, being built up of a number of parallel copper plates, upon which alternating layers of bare copper wire are wound, thus binding them all together. The exciting fluids are concentrated lye for the zinc electrode and sulphate of copper for the copper electrode.

*Battery.*—J. W. Gladstone, West Orange, N. J. Patent 742,857, November 3, 1903. Application filed September 17, 1903.

The invention relates to primary batteries and consists in a mechanical construction for the support of the negative electrode. The latter is held between two perforated clamps, which, by means of a locking device can be pressed tightly against it. In the element described the negative electrode consists of a plate of copper oxide. The positive zinc plates are supported from the cover of the cell, as is the clamping arrangement described above, and have the form of a U-shaped casting.

*Battery.*—J. W. Gladstone, West Orange, N. J. Patent 742,856, November 3, 1903. Application filed September 17, 1903.

The general arrangement of the cell is similar to the one described above, the mechanical construction for clamping the copper oxide plate being different.

*Electric Battery.*—H. Halsey. Patent 743,274, November 3, 1903. Application filed June 23, 1903.

The construction shown in this specification is practically identical with the one dscribed in the preceding specification.

*Electric Battery.*—H. Halsey. Patent 743,273, November 3, 1903. Application filed January 10, 1903.

This cell also contains a movable disc-shaped electrode, and a stationary electrode, the arrangement of the supporting mechanism being somewhat different than the one in the preceding constructions.

*Electric Battery.*—H. Halsey, New York. Patent 743,275, November 3, 1903. Application filed June 23, 1903.

This battery is another one of the inventor's type, with one or both movable electrodes. In this instance the movable electrode is mounted in hangers attached to the underside of the cover, the latter carrying suitable driving mechanism. The movable electrode is stated to be preferably composed of a number of parallel discs mounted on a shaft, and the fixed electrode preferably comprises a number of independent plates electrically connected to a binding post on the cover. A mechanical construction is described by which the several plates of the positive electrode can be readily removed for repairs.

*Electric Battery.*—E. Tweedy, New York. Patent 743,598, November 10, 1903. Application filed December 31, 1902.

The invention relates to two fluid cells, and especially to the arrangement of the diaphragm, in order to keep the latter rigid. The cell is composed of a number of frames, over the sides of which the diaphragms are tightly stretched and tacked. The upper openings of the frames are provided with covers, from which the electrodes depend. The negative element consists of a series of carbon rods. A desired number of sections may thus be built up, after which the assembled cell is placed in a box of larger size and the space between the two vessels filled with melted paraffine in order to make the arrangement fluid tight. Suitable provision is made for locking the covers tight in their position.

*Battery.*—G. Schauli and D. Lowenstein, London, England. Patent 743,337, November 3, 1903. Application filed July 14, 1903.

The invention relates to so-called dry batteries, of the carbon-zinc type. The cell consists of a containing vessel of tinplate, lined internally with a zinc layer. This containing vessel is separated from the zinc electrode proper by a cylinder of paraffined paper, canvas or like substance. The zinc electrode has the shape of a cylinder, closed at the bottom, and is filled with a pulpy exciting mass. The positive carbon electrode, surrounded by a depolarizing agent, is placed inside of the zinc cylinder in the exciting mass. The latter is prepared from rice, the operation of preparing the material consisting in first steeping it in water for one or several days, until a sufficient quantity of malt is formed, then boiling it with the addition of a little water down to a syrupy consistency, whereby, owing to the presence of the malt the greater part of the starch is stated to pass into grape sugar, and then adding salts which serve as electrolytes. It is claimed that the mass thus prepared is considerably less liable to fermentation and dessication than any of the organic substances hitherto employed.

*Electric Battery.* M. R. Hutchinson, Norwood, N. J. Patent 746,514, December 8, 1903. Application filed November 15, 1902.

The object of the invention is to provide a construction for sealing and venting batteries, whereby gases generated in the cell may have a free escape while the liquid is effectively replenished. The invention is especially applicable to cells which are intended to be carried on the person. A construction with these objects in view is described in detail in the specification.

*Electric Battery.* Sakizo Yai, Tokio, Japan. Patent 746,227, December 8, 1903. Application filed May 21, 1903.

The cell is composed of a casing made of zinc or lead plate, and a porous cylinder situated in the casing and preferably formed of blotting or similar paper. The annular space between the latter cylinder and the casing is filled with zinc oxide while the interior of the porous cylinder is filled with a mixture of manganese oxide and graphite powder. In the center of the latter is fixed a carbon or graphite rod. The cover of the casing is provided with an inlet-opening through which a solution of caustic potash is poured in.

MISCELLANEOUS.

*Water Purifier.*—O. M. R. Moeller, Copenhagen, Denmark. Patent 741,690, October 20, 1903. Application filed January 27, 1903.

The apparatus consists of a cylindrical vessel provided with a removable top adapted so as to be lightly clamped in position for the purpose of making a gaslight joint. The electrolytic part of the apparatus is located in the lower part of the cylinder and consists of a number of perforated metallic discs, alternately connected to the anode and cathode. The discs are separated from each other by insulating blocks, and they are separated from the walls of the cylinder by a cylinder of insulating material. The whole structure is so arranged that it can be easily raised and lowered if desirable. The electrolytic part of the apparatus is provided with a conical cover, the object being to collect the gases there. To further insure the action of the gasses liberated by electrolysis on the water to be purified, the upper part of the apparatus is provided with a series of perforated plates, the spaces between which are filled with crushed quartz, broken glass, and sand in the order named. The water enters at the bottom of the apparatus and passes out at the top, but the current can be reversed in order to effectually clean the apparatus.

*Electrolytic Water Purifier.*—G. W. Frazier, Allegheny, Pa. Patent 741,322, October 13, 1903. Application filed January 3, 1903.

The specification describes an apparatus consisting of a casing tube of glass or metal, which is closed by two circular heads with openings for the discharge and introduction of the water to be purified. The upper head also has two openings for the electrodes, which pass through insulating bushings. The electrodes consist of cylindrical metallic discs in contact with metallic cylinders. They are separated by a cross of an insulating material. The lower ring and the electrode resting on it are provided with a central passage, through which the water passes into the apparatus. It then flows outward between the arms of the insulating cross and rises around the upper electrode, finally leaving the apparatus by the outlet at the top. The lower electrode is stationary, but the upper one is furnished with a sliding contact, so that it can descend as it is consumed by electrochemical action. The inventor prefers to make the electrodes of aluminium and the contact discs and conductors of heavily silver-plated metal. The lower electrode is said to serve as anode usually, but an alternating current may also be used. The aluminium hydrate formed by electrolysis acts as a coagulating and purifying agent.

*Ozonator.*—J. Miller and F. M. Ashley, New York. Patent 742,341, October 27, 1903. Application filed December 19, 1902.

The invention has for its object the production of an apparatus in which ozone is generated by silent discharge. The silent discharge medium is a vial shaped body, preferably of glass, the closed end of which is covered with a thin metallic layer of tin-foil, amalgam or the like, and forms one electrode. The other electrode is constituted by a layer of similar material on the inside of the tube, which is extended out of the mouth of the latter and bent back so as to surround the mouth end on the outside. This vial-shaped body is suitably connected with the terminals of a circuit and enclosed in a containing vessel.

*Sugar Making.*—M. H. Miller, Wiarton, Canada. Patent 741,689. October 20, 1903. Application filed November 24, 1902.

The invention is stated to be especially applicable to the manufacture of sugar from beet juice and to the treatment of molasses. The process aims at effecting a most complete purification of the juices preparatory to the crystallization of the sugar. Among the apparatus devised for this purpose are two types of apparatus in which the juice is treated with an electric current in order to effect a separation of albuminous, foreign and coloring matter from it. The first apparatus consists essentially of a cylindrical tank, with a dish-shaped bottom in which a heating coil is disposed. A vertical shaft supported insulated in a step-bearing is placed in the center, and is surrounded by a hollow shaft. The hollow shaft has insulated openings, through which pass the arms of a vertical frame, provided with a number of vertical wires. The outer hollow shaft also carries a frame of the same dimensions, the wires on this frame, however, running horizontal instead of vertical. These frames are rotated by suitable means, and as the inner and outer shafts are connected with the respective terminals of a source of current, the frames are constituted electrodes. On account of this peculiar construction of the frames, the juice is brought into intimate contact with the electrodes, and the albuminous and other foreign matters are separated out. An apparatus of this construction serves for the first treatment of the juice. The second treatment is effected in an apparatus of similar cylindrical form, but without a heating coil. A large porous partition is arranged in the interior, the juice to be treated being placed inside the porous cup, while the outside of the cup is surrounded with water. A number of cylindrical iron cathodes are placed in the outer solution. The anodes inside of the porous cups are supported on a metallic sleeve, which is slipped over an insulating bushing, which, in its turn, is fastened upon a vertical metallic pipe, which serves to introduce the juice to be treated into the apparatus. Upon this sleeve are supported a number of pyramidal frames, preferably of lead or aluminium, the surface of each succeeding lower one being larger than that of the preceding upper one. The juice issues from the central pipe and gradually flowing down over the succeeding frames, is electrolyzed on its way down. The sleeve may also be moved up and down, so as to submerge or move the electrode, as desired. A whole installation of a sugar manufacturing plant, embodying these electric purification apparatus and the necessary filtering, pumping, etc., appliances, is illustrated in the specification.

*Process of Sugar Making.*—M. H. Miller, Wiarton, Canada. Patent 742,127, October 20, 1903. Application filed June 3, 1903.

In this patent the inventor protects the method of carrying out the making of sugar in apparatus described above.

*Apparatus for Converting Oxygen Into Ozone.*—F. S. Blackmarr and J. L. Willford, Minneapolis, Minn. Patent 743,432, November 10, 1903. Application filed April 26, 1902.

The apparatus described in the specification consists essentially of a long glass tube with open ends, which is provided on its outer surface with a number of metallic coils. On its inner surface it carries a number of longitudinal wires. Both sets of wires rest against the surface of the glass, and each of them forms one terminal of the secondary circuit of an induction coil. As the wires are in contact at all points with the tube, sparking is avoided and a "glow" produced around them. Oxygen or air is passed through the tube or along the wall, and thus into the field of the glow produced by the discharge of electricity from the wire. A fan is arranged which acts as an exhaust and draws a continuous stream of air through. Applications of the apparatus for inhaling the ozonized air, for connection with ventilating systems, storage outfits, bath cabinets and the ozonizing of water are described at length and illustrated in the specification.

*Apparatus for Converting Oxygen Into Ozone.*—F. S. Blackmarr and J. L. Wilford, Minneapolis, Minn. Patent 743,433, November 10, 1903. Application filed October 27, 1902.

The apparatus shown in this specification presents an improvement upon the one described above. It consists of a series of glass tubes, with narrow annular spaces between them. These tubes are preferably open at both ends, although the center tube may be closed at the bottom. The terminal of one pole of the induction coil is arranged upon the outside of

the outer tube, and consists of a spirally-wound wire. The intermediate electrodes consist of a series of thin corrugated metal plates, each of which, with its angles of corrugation is in contact with the inner surface of one tube, and the outer surface of the next. All the annular spaces between the tubes are filled in this manner. The innermost tube, which is preferably only open at one end, contains a terminal consisting of a suitably coiled wire. A controller and a cut-out are also provided, the latter serving to regulate the number of terminals which it is desired to have in the circuit, while the controller regulates the current through the terminals.

*Method of Converting Oxygen Into Ozone.*—F. S. Blackmarr and J. L. Wilford, Minneapolis, Minn. Patent 743,431, November 10, 1903. Application filed April 26, 1902.

This specification covers the process of operation with the apparatus described above, which consists in applying an interrupted electric current to the opposite sides of a wall formed of a dielectric substance, such as glass, mica, earthenware, lava, vulcanized rubber or any other suitable material.

*Ozonizer.*—Marius Otto, Paris, France. Patent 744,096, November 14, 1903. Application filed May 29, 1903.

The apparatus consists of a metallic cylinder, either bare or enclosed in a dielectric, which revolves around a vertical axis, and is connected with one pole of a high tension transformer, thus forming one electrode. The cylinder rotates within a thin glass tube, which, on the outside is covered with a metallic conducting layer, which is connected to the second pole of the transformer. Each of the electrodes is divided into portions separated along the generating lines of the cylindrical surfaces in order to avoid short-circuiting.

# Correspondence.

## CONTACT RESISTANCES AND CURRENT LEAKAGES IN AN ELECTROLYTIC COPPER REFINERY.

To the Editor of Electrochemical Industry:

Sir—Regarding Dr. Hutchinson's statements in your January issue I believe he is mistaken in assuming that there has been undue secrecy regarding electrolytic copper refining after the experimental stages were past.

Some electrolytic copper refineries built during the last five years have their power losses down to 10 per cent, or even less, and in 1899 it was appreciated that the plant under discussion could, with slight alterations, reduce its power loss by some 50 per cent, but other matters prohibited this change. There are plants operating now with only a 10 per cent loss, but these are not the cheapest plants to operate from a labor standpoint. Much good might come from experiments whose object is to decrease the power loss while not increasing the cost of labor beyond the power saved. B. Magnus.

Buffalo, N. Y.

## AMERICAN ELECTROCHEMICAL SOCIETY ELECTION.

To the Editor of Electrochemical Industry:

Sir—Mr. C. J. Reed having announced to the Board of Directors of the American Electrochemical Society that he will not accept the duties of the secretaryship, or any other office in the Society to which he has been nominated for the next annual election, the undersigned wishes to announce through your journal that since some nominations have been received proposing that he act as secretary of the Society, in this emergency, that he is willing to serve the Society in any capacity in which the members think he can best aid it and promote its interests, and would take up the duties of secretary and fill them to the best of his ability if his fellow-members wish to elect him to that office.

Joseph W. Richards.

Bethlehem, Pa.

## A BADGE FOR MEMBERS OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

To the Editor of Electrochemical Industry:

Sir—Will you kindly allow me enough space in your valuable journal to call the attention of the members of the American Electrochemical Society to the fact, that, after over two years of organization, and several highly successful conventions, we are yet without any suitable pin or badge. I hope that the coming April convention will take this matter up and adopt one.

I would be glad to hear through your columns from some of the members on this subject.

W. A. McCoy.

Perth Amboy, N. J.

# Current Notes.

American Electrochemical Society.—The following gentlemen were elected members of the American Electrochemical Society at the December meeting of the board of directors: Ross Phillips, Niagara Falls, N. Y.; H. P. Gibbs, Bangalore, India; Heinrich Paweck, Vienna, Austria; Gustave Gin, Paris, France; A. T. Smith, Liverpool, England; J. W. Turrentine, Easton, Pa.; F. L. Slocum, Pittsburg, Pa.; Laurent Lowenberg, Cincinnati, Ohio; J. F. Taylor, Cerro de Pasco, Peru; L. J. Lease, Urbana, Ill.; F. J. Pearson, Chicago, Ill.; Whitman Symmes, San Francisco, Cal.; Fausto Morani, Rome, Italy. At the January meeting of the board of directors the following gentlemen were elected: J. T. McNeier, Philadelphia, Pa.; Kenneth B. Quinan, Somerset, W. Cape Colony; G. L. Townsend, Washington, D. C.; Henry M. Loomis, Niagara Falls, N. Y.; Orion Brooks, San Francisco, Cal.; Charles A. Marie, Paris, France; P. L. T. Heroult, La Praz, France; G. Orth, Nancy, France; Fred. L. Shinn, Madison, Wis.; A. Gandillon, Geneve, Switzerland; A. Solvay, Brussels, Belgium; Louis A. Herdt, Montreal, Can.; William Stanley, Great Barrington, Mass.; Edwin J. Prindle, Washington, D. C.; H. M. Fernberger, Niagara Falls, N. Y.; Frederick Conlin, Bethlehem, Pa.; William L. Dudley, Nashville, Tenn.; Henry P. Talbo, Boston Mass.; Raymond Outwater, Washington, D. C.; Darragh de Lanley, Great Barrington, Mass.; E. R. Barrows, Brandt, Pa.; C. A. Little, Elyria Ohio. At the February meeting of the board of directors the following names will be presented: Archer E. Wheeler, Great Falls, Mont.; Frederick L. Wilder, Morro Velho, Brazil; H. H. Willard, Ann Arbor, Mich.; Murray C. Beebe, Pittsburg, Pa.; Edward Bennett, Pittsburg, Pa.; Frank C. Mathers, Bloomington, Ind.; F. W. MacMahon, London S. E., England; Charles Combes, Paris, France; Henry Carmichael, Boston, Mass.; Charles H. Dennison, Chelsea, Mass.; Gar. A. Roush, Broomington, Ind.

Philadelphia Section of the American Electrochemical Society—The first meeting of this section will be held in the Engineers' Club in Philadelphia, on February 5, the following papers being on the programme: Prof. J. W. Richards, on the electrolysis of mixed solutions; Mr. C. J. Reed, on the thermochemistry of the dissociation theory; Mr. P. G. Salom, on some recent experiments in storage batteries; Mr. Carl Hering, on a few constants in use in electrochemistry; Mr. S. S. Sadtler, on a subject to be announced at the meeting; Dr. Rudolf Gahl, on the theory of electromotive forces, and Mr. E. W. Smith, on the application of thermodynamics in the calculation of electromotive forces.

Manufacture of Achroodextrin and Alcohol.—According to a recent consular report the object of a process of Georges Reynaud, of Paris, relates to manufacturing industrially achroodextrin and alcohol. It consists essentially in soaking the material to be treated in twice its weight of water, and in

heating the resultant mass under pressure in an autoclave or digester at a temperature of 160° to 220° C. for about an hour and a half. Under the influence of this temperature, the cellulose and amylaceous constituents of the treated materials are converted into achroodextrin, which, by reason of its lower density, could advantageously replace ordinary dextrin in its industrial applications. Hitherto achroodextrin has only been known as a laboratory product, because the processes in vogue for the manufacture of dextrin always yield ordinary dextrin, or erythrodextrin. It is said that the new process does not necessitate the presence of any acid or other auxiliary substance, is most economical, and obviates the unavoidable defects connected with the employment of acids, the manipulation being convenient and presenting no danger. As soon as the conversion of the cellulose and amylaceous constituents into achroodextrin is completed, the aqueous solution is withdrawn from the apparatus, and may then be directly employed for industrial exploitation or submitted to a second operation for the purpose of converting it into alcohol. In the latter case, the aqueous solution is heated to 55° C. and then is added a pancreatic juice to produce saccharification, which is completed in about three hours. The liquid is then caused to ferment by the ordinary means, in employing yeast, care being taken to add two-thirds of 1 per cent of acid; when fermentation ceases the liquid is distilled in the usual way. This small quantity of acid may be introduced into the autoclave at the commencement of operations instead of during fermentation.

CLEANING SILVER.—In a daily paper we find a note that silver is easily kept bright if it is boiled occasionally in an aluminium kettle. This latter vessel must be kept perfectly clean and bright, and filled with hot water when the household silver is put in it. Keep the water boiling for fifteen minutes, then take out and dry the silver with the ordinary silver towels, and it will be found that the forks, spoons, etc., will be beautifully bright and glittering. The kettle, on the contrary, will have become tarnished. This note is of interest, since the action which takes place is entirely electrochemical. The tarnish on silver is either $Ag_2S$, $Ag_2O$, or a mixture of both, and the action on these by the voltaic couple formed with the aluminium is similar to Salom's manner of reducing galena, the $Ag_2S$ or $Ag_2O$ being cathode of the voltaic couple and the aluminium anode.

# Book Reviews.

THE PROCEEDINGS OF THE CHEMICAL AND METALLURGICAL SOCIETY OF SOUTH AFRICA, Volume II. (February, 1897, to September, 1899). Johannesburg, Transvaal: Published by the Society; 928 pages. Illustrated. Price, $6.00.

The Chemical and Metallurgical Society of South Africa was founded in 1894, and was nick-named in its early days the "Cyanide Club," since its members were most intensely interested and engaged in the commercial development of the cyanide process. The second volume of the Transactions, which covers the time from February, 1897, to September, 1899, is full of very valuable practical information on the metallurgy of gold. In fact, it may be considered a complete history of the development of gold metallurgy on the Rand during the period mentioned. In view of its importance, we have abstracted those portions which refer to electrolytic precipitation methods, and present them in a separate article elsewhere in this issue. While by far the greatest part of the book has to do with the metallurgy of gold, yet it also contains some interesting papers on other subjects, among them a paper by Loevy on the constitution and effects of liquors (the liquor question being very important in South Africa), a paper by Prister on the manufacture of nitro-explosives, and a paper by Flower-Ellis on the Malay tin industry ("a far cry from Southern Asia to South Africa, from the land of tin to that of gold").

The volume is also highly interesting as a human document. It covers the proceedings of the time just preceding the war. The sturdy pioneers of metallurgical engineering which had come to South Africa from all parts of the world, were surely reigned by a very strong esprit de corps, although there seemed to develop somewhat like a professional jealousy between zinc precipitation and electrolytic precipitation advocates. At some places in the volume we find expressions of political dissatisfaction which indicate the coming war. But the book, as a whole, is a document of very good fellowship and some expressions of friendly sentiment are very touching. When Charles Butters, one of the pioneers of the electrolytic precipitation process in South Africa, left for the United States, Mr. Williams said that he did feel and know that Mr. Butters' name would be remembered and honored among chemists and metallurgists as long as the name of President Krueger and Cecil Rhodes would be remembered in politics.

We hope that the volume may find many readers among engineers and scientists interested either in the practice or theory of the cyanide process. As Mr. Butters says, somewhere in the volume, every one in the United States is intensely interested in the operations in South Africa, but a great deal of work is carried out in the United States laboratories that would be unnecessary if the published results of the practical work on the Rand were given greater circulation than at present. In this sense we hope that the abstracts from the volume, published elsewhere in this issue, on the electrometallurgy of gold, will be welcome to many of our readers, and at the same time we send our greetings to the Society beyond the seas, which now will soon celebrate the tenth anniversary of its formation, and we wish that its success in future may be even greater than in the past.

THE ART OF ILLUMINATION. By Louis Bell, Ph. D., New York: McGraw Publishing Company. 339 pages. Price $2.50.

The purpose which the author had in writing this book, and the object which he has most skillfully attained, was "to set forth some of the fundamental doctrines, optical, physiological and æsthetic, which underlie the proper use of artificial illuminants, and to point out how they may be advantageously adapted to existing conditions."

The scope of the work may be best judged from the headings of the various chapters, viz., light and the eye, principles of color, reflection and diffusion, illuminants of combustion, incandescent burners, the electric incandescent lamp, the electric arc lamp, shades and reflectors, domestic illumination, lighting large interiors, street and exterior illumination, decorative and scenic illumination, standards of light and photometry, the illumination of the future.

As regards the manner of treatment, it may truly be said that the author unites the accuracy of a scientist with the perceptions of an artist. The work is not mathematical nor severely scientific, yet it is scientifically accurate; it is not a refined philosophical or psychological essay on the perceptions of color or the physiological effect of light, yet it is philosophical and artistically pleasing in a manner within the range and capacity of every educated reader.

About the only criticism we would venture is that the industrial value of acetylene is not properly appreciated. The author hardly gives this gas the full credit which its present use bespeaks, and certainly does not fully gauge the possibilities of cheaper acetylene. A large proportion of the extent of even the most civilized countries is entirely outside of the range of municipal gas supply, and a considerable proportion outside of the range of electrical illumination, and for all such areas acetylene is probably the coming illuminant, whenever anything more brilliant than the kerosene lamp is desired. Incidentally, this means a still greater extension of one of the largest of the electrochemical industries.

Dr. Bell's book may be recommended not only to the professional "illuminator," or architect, or physicist, as a book which they should all "read, mark, learn and inwardly digest," but we would cordially recommend its perusal to everybody who has need of illumination of any kind, and who wishes to know how best to choose and to use it.

Die Electrochemie und Metallurgie auf der Industrie und Gewerbe Ausstellung in Duesseldorf, 1902. By H. Danneel. Halle a. S.: W. Knapp. Price $2.00.

This book is amplified from an article by the author in the *Zeitschrift für Elektrochemie*. It describes the varied exhibits at the late exposition in the hustling German town of Duesseldorf.

Electrochemists in general will be interested in the descriptions of the various electrochemical products and processes, such as Elmore's, that of calcium carbide, etc. The description of the electrical measuring instruments, electric furnaces and pyrometers can be recommended.

## ELECTROLYTIC RECTIFIER AND INTERRUPTER.

For several years attempts have been made to utilize for practical purposes the well-known property of an aluminium electrode to permit a current to pass freely in one direction, and to offer a strong resistance to its flow in the opposite direction. This property seems to have been first discovered by Wheatstone in 1855, and has long been the object of investigations made with a view of utilizing it for the design of an electrolytic rectifier.

In the first attempts a single cell was used, with one aluminium electrode, the other electrode being of another suitable metal. If an alternating current is impressed on such a cell, it should allow only one-half of each wave of the alternating current to pass, and a uni-directional (although pulsating) current would be obtained. In reality, however, the aluminium anode is not a perfect valve, since it allows a small leakage current to pass, so that a single cell of the above description does not give a uni-directional current, but an alternating current, although with one alternation of greater amplitude than the other. The practical result in charging a storage battery is that the efficiency is low. The battery is correctly charged during one-half wave, but is somewhat (although not fully) discharged again by the next half-wave. The efficiency is therefore generally not more than 20 per cent.

The next step in the development of the rectifier was made by Graetz, who used a combination of four rectifying cells, and really obtained a true uni-directional current. But the efficiency was low, and the combination complicated.

In the Churcher rectifier, built by the Electric Appliance Co., of Cincinnati, Ohio, a single cell is used, and a high efficiency is claimed for its operation. There is a small leakage current, but it does not pass through the apparatus operated by direct current, and would therefore not discharge a battery that is to be charged, but is expended in heating the solution. This loss depends largely upon the initial formation of the oxide film of the aluminium, the purity of the aluminium, and the solution, and on the temperature which should not become too high. Where continuous service is required of the rectifier, it is desirable to prevent the rise of temperature by a method of water-cooling.

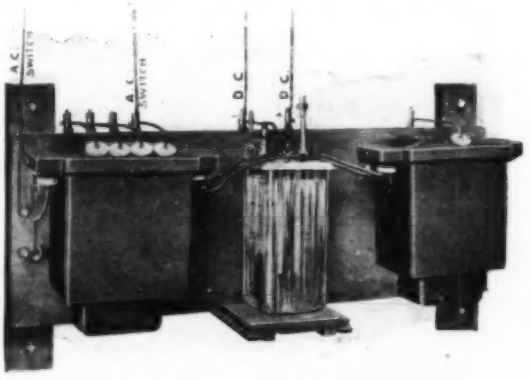
The Churcher rectifier is used in connection with a transformer, the secondary of which is designed for twice the direct-current voltage required plus the resistance loss. This secondary coil is tapped in the center, and by virtue of the action of the rectifier this tap remains positive at all times.

Each of the two terminals of the secondary coil is connected with an aluminium electrode in the rectifier. Owing to the film on either of these electrodes no appreciable current passes between them (otherwise the transformer would be short-circuited). Between these active electrodes, but insulated from them, is placed an inactive electrode of platinum, and between the latter and the center tap of the secondary of the transformer, there is connected the battery to be charged or the direct-current motor or the electrolytic or plating cell to be operated.

During operation the current passes from the center tap of the transformer to the battery to be charged, then to the platinum electrode in the rectifier (which is therefore always anode) and from it to one or the other aluminium electrode according to which is at that instant negative to the center of the transformer. It will thus be seen that one side of the transformer is active, while the other is inactive, and then reversed during the next alternation.

The regulation of the direct current is best attained by placing an adjustable inductance between the transformer terminals and the aluminium electrodes of the rectifier, or it may be accomplished by an inductance in the main alternating supply, or by varying the number of turns in the primary of the transformer. This form of regulation is much more efficient than placing resistance in series with storage batteries when charging from 110-volt direct-current mains. The latter method is, of course, simply a waste of energy.

That the uni-directional current which passes through the battery is pulsating, is considered an advantage, since it is claimed to have been found in practice that a pulsating uni-




ELECTROLYTIC RECTIFIER.

directional current is better for charging a battery than a perfectly uniform continuous current.

By the use of two cells and two secondaries in the one transformer, twice the voltage may be obtained. By using three cells with three secondaries in the one transformer, three times the voltage is produced, etc. It is thus quite clear that the regulation is very easy.

The adjoining illustration shows a 50-volt rectifier, with a capacity of 20 amperes. The Electric Appliance Co. builds rectifiers for the following capacities: Fifty volts, and 10 or 20 amperes; 70 volts, and 30 amperes; 100 volts, and 20 amperes, and smaller ones for 25 volts, and 1 or 2 amperes, and 50 volts, and 2 amperes.

While the charging of storage batteries from alternating-current mains is probably the main industrial application at present, yet there should be a wide field for a reliable rectifier in electrochemistry in all such cases where only alternating current is available, and direct current is required for electrolytic purpose. The above information is taken from an interesting paper presented by Mr. W. B. Churcher to the Northwestern Electrical Association at Milwaukee.

## VACUUM DRYING APPARATUS.

The process of evaporating liquids in vacuo has long been practiced, on account of its many advantages, among which may be mentioned the great saving in time, the feasibility of reclaiming valuable solvents, the control of noxious vapors,

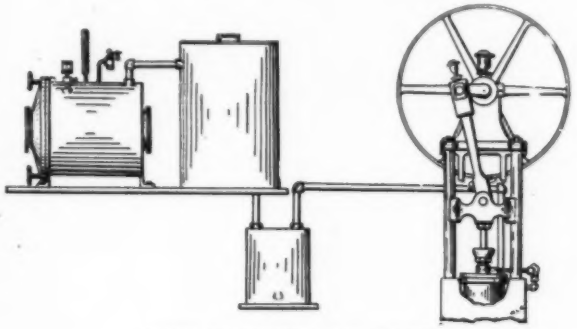
and the increased quantity and superior quality of the product due to the lower temperature at which the process may be carried on, and to the exclusion of air during the operation. For many substances which, on account of their nature, must be dried at a low temperature, drying in vacuo is in especially extended use.

There are at least three different methods and types of apparatus employed in the vacuum process, namely: first, the vacuum pan method, for the concentration of liquids, in which a pan, a jet condenser, and a vacuum pump are used, and in which method the condensed vapors are discharged simultaneously with the condensation water, and are not recovered. This is known as the "wet system" of working in vacuo. Secondly, the vacuum still method, in which are used a closed pan, a surface condenser, a receiver of the distilled solvent, and a vacuum pump. Thirdly, the vacuum dryer method, consisting of a vacuum chamber, a surface condenser, a vacuum pump, and a receiver of the solvent if it is to be reclaimed.

The apparatus built by the American Vacuum Drying Machine Co., of New York City, one type of which is shown in the adjoining illustration, employs the features of the third method, drying the material in a very short time, and, if desired, recovering in the same operation the valuable solvents, such as alcohol, ether, etc.

The temperature in the drying chamber can be regulated with precision, oxidation with its detrimental effects is altogether avoided, noxious fumes are harmlessly discharged at any desired point, and the material treated by this process is of very uniform quality.

The stationary American Vacuum Drying Machine proper consists of a cylindrical or rectangular chamber, within which are placed, at suitable distances apart, hollow metal shelves, through which either direct steam at low pressure, exhaust



VACUUM DRYING APPARATUS.

steam or hot water, is circulated; or, if steam at high pressure is to be utilized, coils of pipe, arranged to serve as shelves, are employed.

The pans or trays containing the material to be dried are placed on the heated shelves, after which the hinged and air-tight doors are closed, whereupon the air and vapors are withdrawn from the drying chamber by means of the condensing apparatus, and, if it is desired to reclaim valuable solvents in the same operation, a receiver is connected with the surface condenser or with the pump.

When, however, it is necessary to meet the requirements of any particular shape of materials to be dried, and to which the above-mentioned shelves may not be adapted, other suitable interior arrangements may, of course, be used in place of such shelves; for instance, vacuum tunnels, in which suitable cars are operated on a track so that the largest quantities can be handled.

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The C. W. Hunt Co., of West New Brighton, N. Y., have issued a very neatly illustrated pamphlet on "industrial" narrow-gauge railways, which gives much valuable information on this subject.

## GENERATORS FOR ELECTROPLATING, ELECTROTYPING AND OTHER ELECTROLYTIC WORK.

On pages 40 and 296 of Vol. I. we have described in detail the construction of the "Eddy" machines for electroplating, electrotyping and other electrolytic work, which are now being manufactured by the General Electric Co. From bulletin 4350 of this company we gather the following additional information on the use of these machines for plating work. While it contains nothing of special novelty, yet the information is given in such a simple form as to be readily understood by every practical electroplater.

When the anode in an electroplating tank is of the same metal as that with which it is desired to coat the cathode, no voltage would be required to do the plating, were it not for the resistance of the solution. The e. m. f. required at the terminals of a plating vat must be slightly above that for overcoming the internal resistance of the cell, and depends, therefore, on the nature of the solution, its temperature, the surface exposed by both anode and cathode, the distance between them, and the current density per unit of plate area (amperes per square foot).

If the anode is made of a material unaffected by the solution, then the voltage required will be that needed to overcome the resistance, plus that necessary to break up the metal-carrying compound in solution (for $CuSO_4$ — 1.21 volts, $PbSO_4$ — 1.61 volts, etc.) and in this case the metal-carrying compound must be added to the solution when necessary, as otherwise the plating would soon cease, owing to the absence of metal.

While it is true that a certain number of ampere hours will always reduce the same amount of metal from a given solution, the electroplater desires the deposited coating to be more or less reguline, and it has been found that in order to obtain a suitable deposit it is necessary to limit the number of amperes per square foot of cathode surface, or the rate of deposition. The rate of deposition for a given grade of coating has been found to be considerably affected, in many cases, by the temperature at which the solution is used, and may be largely increased by giving motion to the cathode or agitating the solution. There are many solutions from which no satisfactory deposits can be obtained, and some solutions cannot be used with certain cathodes, for example, $CuSO_4$ cannot be used with cathodes of Fe and Zn.

Theoretical efficiency, both with regard to voltage required and output per ampere hour, is seldom obtained outside of the laboratory, due to impurities, secondary reactions, polarization, etc., but in most cases these troubles are of minor importance and considerably more than 95 per cent of the theoretical amount of metal per ampere hour is often obtained in ordinary practice.

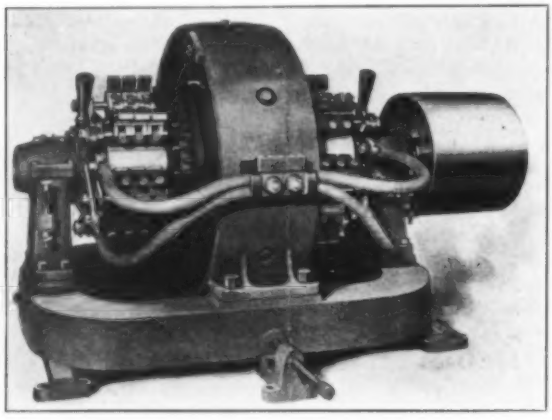
The old practice of rating electroplating machines by the number of gallons of certain solutions they could supply with current, is not only inaccurate, but very misleading, as the current required for a given volume of solution depends on the cathode surface exposed to it, and the permissible current density. It varies, therefore, with the size and form of the objects to be plated, and the grade of deposit desired. One grade of work may require two or three times as much solution for the same amount of deposit as another grade.

If the machines be rated in amperes there should be no doubt as to what is meant, as a given number of ampere hours will deposit a certain weight of metal, or will cover a certain number of square feet of cathode surface with a given thickness of film.

One thousand ampere hours, when used in a suitable bath, will theoretically deposit approximately the folloying weights of metals:

| | | | |
|---|---|---|---|
| Cu (copper) | 41.8 | oz. | Avoir. |
| Ni (nickel) | 38.6 | " | " |
| Brass | 42 | " | " |
| Zn (zinc) | 43 | " | " |
| Ag (silver) | 129 | " | Troy |
| Au (gold) | 78.8 | " | " |

The following table gives the theoretical rates of deposition per hour, at full load, for the different machines, but if two or more tanks are used in series, the amount will be found by

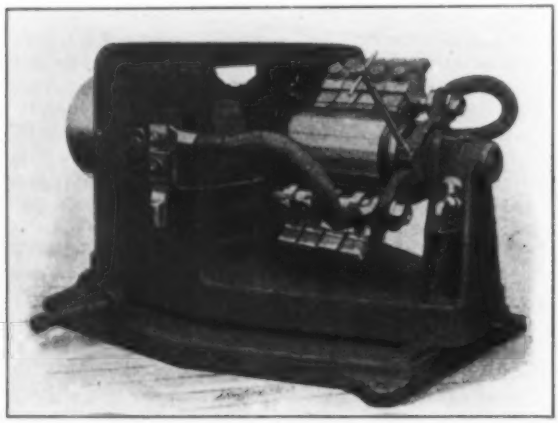


ELECTROPLATING DYNAMO, 6 TO 12 VOLTS, 2000 TO 1000 AMPERES.

multiplying that given below by the number of tanks in series. The actual rate will, in most cases, be slightly less.

| Amperes. | Oz. Avoir. Per Hour. | | | | Oz. Troy Per Hour. | |
|---|---|---|---|---|---|---|
| | Copper. | Nickel. | Brass. | Zinc. | Silver. | Gold. |
| 150 | 6.25 | 5.75 | 6.3 | 6.4 | 19.4 | 11.8 |
| 300 | 12.5 | 11.5 | 12.6 | 12.9 | 38.3 | 23.6 |
| 600 | 25.1 | 23.1 | 25.2 | 25.8 | 77.6 | 47.3 |
| 900 | 37.6 | 34.7 | 37.8 | 38.7 | 116 | 71 |
| 1000 | 41.8 | 38.6 | 42 | 43 | 129.4 | 78.8 |
| 1500 | 62.8 | 57.9 | 63 | 64.5 | 194 | 118.2 |
| 2000 | 83.6 | 77.2 | 84 | 86 | 258.8 | 157.6 |
| 2500 | 104.6 | 96.5 | 105 | 107.5 | 323.4 | 197 |

96,538.5 coulombs is given as the ionic charge per univalent gramion, or practically 96,540, and even if the name and meaning of this constant should be considered of little value to the practical electroplater, the constant itself may be used by them to considerable advantage. Let $a$ equal the chemical equivalent of any element; that is, its atomic weight divided by its valency, or cimbining power, then, $a \times 3600 \div 96{,}540$



ELECTROPLATING DYNAMO, 5-VOLT, 150 AMP.

grams of the element are liberated per ampere hour, and $96{,}540 \div (3600\ a)$ ampere hours are required to liberate one gram.

1 oz. Avoir. = 28.35 grams; 1 oz. Troy = 31.1 grams.

Dividing the result obtained from the first equation by the grams per oz. will give the ounces per ampere hour, and multiplying the result obtained from the second equation by the grams per oz. will give the ampere hours required per oz.

For example, the atomic weight of silver is 107.93 (Hering), valency 1, and therefore chemical equivalent 107.93. From $107.93 \times 3600 \div 96{,}540$ we get 4.025 grams per ampere hour. is, divided by 31.1 = 0.1294 oz. Troy per ampere hour, or 129.4 oz. Troy per 1000 ampere hours.

As the voltage required for plating with like anodes is independent of the metal deposited, and is determined by the resistance of the solution, etc., the determining conditions being so variable we should expect a large variation in the voltages used, and this is found to be the case.

The following, however, gives the ordinary limits in actual use:

| | | | | |
|---|---|---|---|---|
| Copper sulphate | 0.2 | to | 2 | volts |
| Copper cyanide | 2 | " | 5 | " |
| Nickel | 1 | " | 6 | " |
| Brass | 2 | " | 6 | " |
| Silver | 0.3 | " | 1 | " |
| Gold | 0.5 | " | 3 | " |

The rate of deposition, or amperes per square foot of cathode surface used, also varies largely, depending on the grade

ELECTROPLATING DYNAMO, 5 TO 10 VOLTS, 600 TO 300 AMP.

of deposit desired, the nature of the solution, its temperature and whether it is used still or agitated. In fact, a rate as high as 500 amperes per square foot has been used with copper, and a reguline deposit obtained under proper conditions. (Mailloux.)

The following are the rates in ordinary use:

| | | | | | | |
|---|---|---|---|---|---|---|
| Copper sulphate | 2 | to | 150 | amps. | per | sq. ft. |
| Copper cyanide | 3 | " | 40 | " | " | " |
| Nickel | 1 | " | 30 | " | " | " |
| Brass | 3 | " | 20 | " | " | " |
| Zinc | 2 | " | 18 | " | " | " |
| Silver | 1 | " | 10 | " | " | " |
| Gold | 1 | " | 8 | " | " | " |

Electrorefining is practically electroplating, the metal to be refined being used in its impure state as the anode, and such a solution used that all the impurities are either held in suspension, or fall to the bottom, and only the pure metal is deposited on the cathode.

## PERSONAL.

Mr. E. Stütz delivered a lecture on aluminothermics before the Franklin Institute, of Philadelphia, on January 20, and will deliver another lecture before the Boston Section of the American Chemical Society at the Massachusetts Institute of Technology on February 25t

On December 19, 1903, the twenty-fifth anniversary of the day on which Prof. WILHELM OSTWALD received the degree of Ph. D., with his thesis "Volum-chemische und optisch-chemische Studien," was celebrated in Leipzig. Among the speakers who presented their congratulations to the famous scientist were Van't Hoff, Walden, Trey, Wagner, Landolt, LeBlanc, von Oettingen, Stein (who spoke of Ostwald as philosopher), Lepsius and Arrhenius. Congratulatory telegrams were received from all parts of the world, among them from the following cities in America: Ann Arbor, Mich.; Baltimore, Berkeley, Cal.; Ithaca, N. Y., and Toronto, Canada. Van't Hoff presented the Ostwald "Jubelband," a large volume containing papers from many former students of Ostwald.

## INDUSTRIAL NOTES

INSULATORS.—We have received from Mr. C. S. Knowles, Boston, catalogue 20, on glass and porcelain insulators.

PAINTS.—We have received from Mr. A. Grothwell, San Francisco, an illustrated booklet on the various uses of his "Mogul" paint.

The LAIDLAW-DUNN-GORDON Co., of Cincinnati, have sent us bulletin L-509 on Meyer gear air compressors, with rolling-mill frames.

Messrs. SAUVEUR & WHITING, of Boston, Mass., announce that they are now prepared to give an elementary course in metallography by correspondence.

We have received from Messrs. S. B. CONDIT, JR., & Co., of Boston, their bulletin C-22, on Elder automatic circuit breakers, single pole, direct and alternating current.

MOTOR-VEHICLES.—Circular 1059 of the Westinghouse Electric & Manufacturing Co. deals with electric motor-vehicle equipments. Illustrated descriptions are given of automobile motors, controllers, and accessories, like battery indicators, charging receptacle, battery contacts, etc.

ELECTROLYTIC GENERATORS.—Bulletin 4,350, of the GENERAL ELECTRIC Co., deals with generators for electroplating and electrotyping and other electrolytic work, which were already described on page 40 (Eddy Manufacturing Co.) and page 296 of Vol. I. of this journal. Some interesting details given in the bulletin will be referred to in our next issue.

Bulletin 1049 of the Fort Wayne Electric Works gives a list of plants operating types MP and MPL, direct-connected, direct-current generators. Bulletin 1050 gives a description of direct-connected type MPL, direct-current generators for power and lighting. Bulletin 1051 gives a list of plants operating single-phase alternators in the United States.

We have received from MESSRS. QUEEN & Co., INC., of Philadelphia, their neatly illustrated pamphlet with the title "Fifty Years, 1853-1903." The firm was established by James W. Queen, in 1853. The pamphlet contains illustrated notes on the firm's optical, mathematical, engineering, microscopical, physical, electrical, meteorological, astronomical, photographic and chemical departments and factories.

SUCTION PRODUCER GAS FOR POWER.—The S. R. Smythe Co., of Pittsburg, Pa., represented in New York by Dr. Oskar Nagel, has issued a catalogue on Suction Gas Producers for Gas Engines, showing the simplicity and advantages of the construction and the economy in fuel attained thereby. These producers are built in units from 5 to 150 hp., and are stated to yield 1 hp. hour per pound of coal. No boiler or gasholder is required.

ASBESTOS THEATER CURTAINS.—The H. W. Johns-Manville Co., of New York City, have sent us a pamphlet on asbestos theater curtains, with some samples of asbestos cloth. The theater curtains made by this company are pure asbestos, interwoven with brass wire, to produce sufficient tensile strength. It is suggested that the major part of the scenery on the stage, as well as all the upholstery and carpets, could be made of asbestos cloth, thus diminishing the dangers of theater fires very considerably.

NIAGRITE.—A material for preventing loss by fire, and danger to life from the short-circuiting of high-voltage electrical wires, for which the trade-mark "Niagrite" has been adopted, is being placed upon the market by the H. W. Johns-Manville Co., of New York City. "Niagrite" is furnished in strips of several widths, from 3 inches to 36 inches, and is held in place by asbestos fireproof glue, thus protecting the cables from external fire and confining the internal fire. The material presents a very neat and permanent finish, and is not affected by atmospheric conditions.

AIR COMPRESSORS.—A new line of air compressors is described in bulletin L-509, recently issued by the Laidlaw-Dunn-Gordon Co., of New York City. These compressors are fitted with Meyer steam-valve gears, permitting of an adjustable cut-off. The air ends are arranged both with poppet inlet and outlet valves, and with mechanically operated inlet and poppet outlet valves, the valves in either case being placed in the head of the cylinder, permitting the body to be effectively water-jacketed. The frames of the compressors are specially heavy. The capacities listed range from 468 to 2220 cubic feet of free air per minute, and the air pressures from 80 to 100 pounds per square inch.

ALUMINOTHERMICS.—Mr. E. Stütz, of New York City, who represents in this country, the thermit process, controlled by the chemical and tin smelting works of Th. Goldschmidt, Essen-Ruhr, Germany, announces that he is now in a position to supply thermit and appliances such as crucibles, etc., from stock in New York. A number of pamphlets have been prepared, giving instructions in a concise form. The great interest aroused by Dr. Goldschmidt's lectures of last year has rendered necessary the import of thermit and accessories from Germany, until the preparations have been completed for manufacture in this country. The offices of Mr. E. Stütz have been transferred to Wall Street Exchange Building, 43-47 Exchange Place, New York City.

ELECTRIC LIGHTING OF RAILWAY CARS BY STORAGE BATTERIES.—Catalogue 110, of the DAYTON MANUFACTURING Co., of Dayton, Ohio, deals with the use of the Silvey storage battery for lighting railway cars. The Silvey system is extremely simple, every variety of automatic devices being left out. No dynamos are carried on the train. The entire apparatus consists of storage batteries, 24-volt, 2.5-watt lamps, and the switch for turning on of the current. Each car is provided with its own individual battery, and its lighting system is an entirely independent unit. The batteries are charged at the terminals of the road, when it does not exceed 2,000 miles in length, since the battery on the car provides sufficient current for a run of 2,000 miles without any attention. The catalogue contains a great many extremely pretty half-tones.

THE LOOMIS-PETTIBONE GAS MACHINERY Co., has been merged with the Holthoff Machinery Co., of Milwaukee, under the new coporation name of Power and Mining Machinery Co. Extensive improvements and additions are made to the Milwaukee plant for the manufacture of the American Crossley gas engines, Loomis-Pettibone gas apparatus, and Holthoff mining metallurgical machinery. We have received from this company their pamphlet on gas for furnace work. By their system bituminous or anthracite coal, coke or wood can be burned. Some figures are given to show a saving of over a hundred per cent with the use of gas fired furnaces over that of oil fired furnaces. A fixed clean gas is produced, that can be conveyed over desired distances through cast or wrought iron pipes, thus obviating the necessity of numerous small coal piles scattered throughout the works. Some notes are given on the new plant of the Pennsylvania Steel Co., at Steelton, Pa.

Pelton Wheels.—A large order for Pelton water-wheels is being completed for the Columbia Improvement Company, near Tacoma, Wash. The installation consists of four Pelton units, aggregating 31,000 hp., operating under an 850-ft. head. These are the largest water-wheel units in the world, with the exception of those at Niagara Falls.

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## DIGEST OF U. S. PATENTS

Prior to July, 1902.

*Compiled by Byrnes & Townsend,*
*Patent Lawyers,*
*National Union Building, Washington, D. C.*

634,271. October 3, 1899. Henri Plater-Syberg, Paris, France.

Method of making acetic acid. An alkali acetate is produced by digestion of wood or moss rich in carbohydrates in hot concentrated alkali solution with injection of air. The resulting crude acetate is electrolyzed in diaphragm cell with anode and cathode of iron, yielding at the anode ferrous acetate and at the cathode the hydrate of the alkali. The ferrous acetate is dried, pulverized and oxidized by air to ferric acetate, which is decomposed with neutral alkali acetate, whereby the iron is precipitated as hydrate and the biacetate of the alkali is formed. This biacetate separates on heating into acetic acid and neutral acetate. The cathode lye is employed for digestion of fresh quantities of wood.

644,050. February 27, 1900. Hermann Beckmann, Witten, Germany.

Lead peroxide is formed by the anodic oxidation of lead in a solution containing free suphurous acid. Is applied mainly to the formation of Planté plates, the advantage being that no substances detrimental to the duration of the electrodes are employed.

651,396. June 12, 1900. E. A. G. Street, Paris, France.

Chromium hydroxide is produced by the electrolysis of chromate or bichromate solutions with a cathode of mercury, preferably at a temperature of 70° C. It is stated that the formation of the chromic hydroxide depends upon the presence of metallic sodium, as sodium amalgam. A platinum anode may be used, or the anode may be of mercury; in the latter case insoluble mercury chromate is formed on the anode and may be transformed into chromic hydroxide and mercury by reversal of the current.

650,536. May 29, 1900. Arthur Hough, San Francisco, Cal.

Mannite is produced by electrolytic reduction of glucose solutions. A diaphragm cell is preferably, but not necessarily used, the anode compartment containing water, and the cathode compartment the glucose solution. The mannite is produced directly by addition of hydrogen, and may be recovered from the solution by evaporation. Reference is made to the previous method involving the use of sodium amalgam.

662,585. November 27, 1900. George H. Benjamin, New York, N. Y.

Produces diethyl-ether by the joint action of ethylene, hydrogen and oxygen, on hydrogen-ethyl sulphate. The method is electrolytic only in that the hydrogen and oxygen are preferably produced by electrolysis of water in presence of the remaining compounds.

665,244. January 1, 1901. Paul Magnier, Billancourt, France.

Sponifies fatty substances, such as tallow, oils, vegetable butter and oleic acid. To the fatty substance liquid or liquefied by dissolving it in oleic acid or oil, is slowly added sulphuric acid, the liquid being continuously stirred, and the mixture is allowed to stand for a few hours. The amount of sulphuric acid required may be reduced from 50 to 10 or 12 per cent by adding it drop by drop, and to 6 per cent by simultaneously heating the fatty body to 80° C. To the product is added five or six times its weight of hot water, and the resulting emulsion is introduced into a metallic digesting vessel, which serves as an electrode, another electrode of carbon being suspended therein. The digester is closed and heated to a temperature sufficient to create an internal pressure of from three to five kilograms per square centimeter. An electric current is then passed through the mass, until the saponification is complete. The fatty acids float to the surface, while the glycerine and sulphuric acid remain dissolved in the mother-lye. Any free oleic acid added to or present in the emulsion is largely converted into solid fatty acids. The magma is removed and subjected to the usual treatment for the manufacture of stearin.

665,783. January 8, 1901. Henry K. Hess, Philadelphia, Pa.

Regenerates the spent liquids of two-fluid batteries containing respectively chromium sulphate and zinc sulphate. The chromium sulphate solution is placed in porous cups containing the anodes, which may be granulated lead filling the cups, corrugated sheet lead, graphite or platinum. The cups are placed in a vessel containing the zinc solution. A vertical series of trays containing mercury, serving as cathodes, are placed in the zinc solution; or amalgamated copper-plate cathodes may be used. The electric current reoxidizes the chromium solution to chromic and sulphuric acid and the zinc is deposited in the mercury or on the copper plates.

670,201. March 19, 1901. Edward D. Kendall, Brooklyn, N. Y.

Produces zinc oxide and sodium nitrite by electrolyzing a saturated solution of Chili saltpeter, employing anodes of zinc and cathodes of copper, iron, tin-plate or lead. The vessel may serve as cathode. Potential difference 6 volts. The zinc oxide separates from the anode and precipitate to the bottom of the vessel, where it is collected in a tray.

679,985. August 6, 1901. Hippolyte Palas and Felix Cotta, Marseilles, France.

Produces copper sulphate and caustic alkali in a cell having double diaphragms, consisting of two spaced asbestos sheets, which are externally supported by wood or glass grids. The cell is built up of rectangular wooden frames, having but three sides, between which the diaphrgms are clamped. The anodes are of copper or other metal whose sulphate is desired, in the form of plates, strips, waste, chips, ores, or copper pyrites residues. The cathods are iron plates. A copper sulphate solution is placed in the anode compartment and an alkali sulphate solution in the cathode and diaphragm compartments. The alkali solution is continuously introduced into the diaphragms, maintaining therein a slight head, which causes a circulation through the diaphragm walls and prevents oxides from being precipitated therein. Potential difference, 2.5 to 3 volts.

680,543. August 13, 1901. Wilhelm Pip, Darmstadt, Germany.

Refers to an unsuccessful prior attempt to produce piperidin from pyridin by electrolyzing a solution of ten parts of pyridin in 100 parts of 10 per cent sulphuric acid, using lead cathodes. Renders the process successful by employing pure acid, and at least three equivalents of acid to one of pyridin, using electrodes of lead, carbon, mercury or silver. Hydrochloric acid may be substituted for sulphuric. Example: 10 kilograms of pyridin are dissolved in 110 kilograms of water and 25 kilograms of 65° Be. sulphuric acid and placed in the cathode compartment of a diaphragm cell having both electrodes of lead. The anode compartment is filled with a solution of 5 kilograms of 66° Be. sulphuric acid in 50 kilograms of water. If clay diaphragms are used, they should be free from easily-decomposable iron silicates or other soluble salts, carbonates, etc. A less advantageous method consists in electrolyzing the same pyridin solution in a cell without diaphragm. In either case, the preferred cathode current density is 4.5 amperes per square decimeter.